I. C. 6972

November 1937

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

GOLD LODE MINING IN THE TOBACCO ROOT MOUNTAINS, MADISON COUNTY, MONT.

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

GOLD LODE MINING IN THE TOBACCO ROOT MOUNTAINS, MADISON COUNTY, MONT.[1]

By S. H. Lorain[2]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6972."

[2] Mining engineer, Mining Division, Metal Mining Methods Section, Bureau of Mines.

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INTRODUCTION

This paper is one of a series being published by the Bureau of Mines describing the mines and mills and subjects related to mining in western mineral areas.

Although mining districts in the Tobacco Root Mountains are numerous there is a strong similarity in the character of the ore deposits and in the climatic and economic conditions affecting mining throughout the region.

Individual mines are small, but the production of lode mines has totaled at least $17,000,000. An additional $50,000,000 or more, about four-fifths of which was mined prior to 1900, has been produced from gold placers.

The recent increase in the price of gold has injected new life into this region which, although one of the oldest mining districts in the West, shows no indication of approaching exhaustion.

The field survey upon which this paper is based was made during the summer of 1936.

ACKNOWLEDGMENTS

The operators in the region freely supplied all information that was available and contributed generously of their time in conducting the writer through their mines and mills.

The geology of many of the districts and mines was described by A. N. Winchell in 1914.[3]

The areal geology was mapped and described in considerable detail by Wilfred Tansley and Paul A. Schafer in 1933.[4]

The geology of the mining districts and of many of the mines was described by Lyman H. Hart in 1933.[5]

The tables of production were compiled by Thomas H. Miller, of the Mineral Production and Economics Division of the United States Bureau of Mines.

Officials of the Montana Power Co., the Chicago, Milwaukee & St. Paul Ry., the Northern Pacific Ry., the United States Weather Bureau, and the United States Forest Service supplied information pertaining to their respective activities within the region.

Other information was obtained from various sources for which credit is given in the text.

LOCATION

The Tobacco Root Mountains are in southwestern Montana (fig. 1) and form the divide between the Ruby-Jefferson and Madison Rivers. The northern

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[3] Winchell, A. N., Mining Districts of the Dillon Quadrangle, Mont., and Adjacent Areas: Geol. Survey Bull. 574, 1914, 191 pp.

[4] Tansley, Wilfred, and Schafer, Paul A., A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Mont.: Montana Bureau of Mines and Geology, Mem. 9, pt. 1.

[5] Hart, Lyman H., A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Mont.: Montana Bureau of Mines and Geology, Mem. 9, pt. 2.

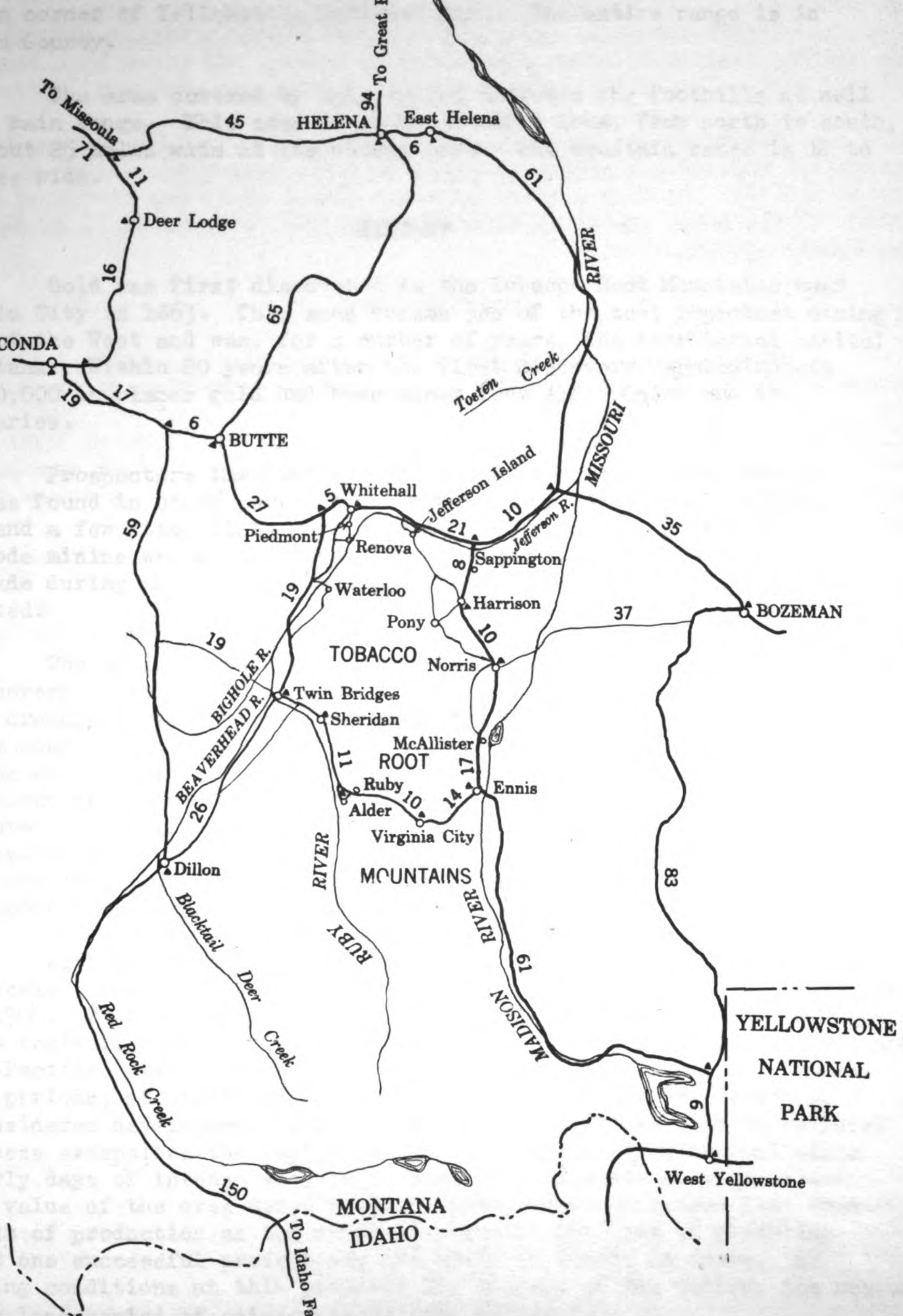

Figure 1.—Road map of southwestern Montana adjacent to Tobacco Root Mountains, giving distance in miles between important points.

end of the range is about 20 miles, in a straight line, southeast of the city of Butte; the southern end is about 30 miles northwest of the northwestern corner of Yellowstone National Park. The entire range is in Madison County.

The area covered by this report includes the foothills as well as the main range. This area is about 35 miles long, from north to south, and about 25 miles wide at its widest part. The mountain range is 12 to 16 miles wide.

HISTORY

Gold was first discovered in the Tobacco Root Mountains near Virginia City in 1863. This soon became one of the most important mining camps of the West and was, for a number of years, the territorial capital of Montana. Within 20 years after the first discovery, approximately $30,000,000 in placer gold had been mined from Alder Gulch and its tributaries.

Prospectors immediately spread out to nearby areas, placer gold was found in other parts of the range, many lode locations were made, and a few stamp mills were operated before 1870. From 1870 to 1900 lode mining was most active. Most of the locations known today were made during this period, and a number of mines were successfully exploited.

The mills of this period depended chiefly upon amalgamation for the recovery of gold. Consequently, when the upper, oxidized portions of the oreshoots were exhausted, recoveries fell off. Even if a satisfactory concentration of sulphides had been possible, transportation and smelting costs would frequently have been prohibitive. Furthermore, development below the zone of oxidation often entailed pumping considerable water which, with the high cost of fuel and the inefficient equipment available, increased costs to the point where operation was no longer possible. To this day few mines have been explored below the water table except where sidehill operation permitted natural drainage.

Although some mines have produced more or less consistently on a small scale since their discovery, mining has been spasmodic in the region since 1900. Each major business depression has been followed or accompanied by some revival; a few mines, notably the Boss Tweed, Mammoth, Revenue, and Easton-Pacific, were operated on a comparatively large scale for considerable periods; at other properties large sums of money were spent on ill-considered development projects which inevitably resulted in failure. With these exceptions the region has been comparatively quiescent since the early days of intense activity. Unquestionably the average recoverable value of the ores mined by nonselective methods became less than the cost of production as the depth increased. The cost of producing gold at one successful present-day operation is $20.80 an ounce. As operating conditions at this property are typical of the region, the reason for the long period of quiescence becomes apparent.

Higher prices for gold have revived mining activity throughout the region; newly undertaken operations at several old mines have been notably successful, encouraging a steadily increasing number of operators.

Placer mining was at its height from 1860 to 1890, after which production gradually fell off until large-scale placer operations virtually ceased in 1923. In 1935 a large dragline placer plant was installed on Alder Gulch; in the summer of 1936 about 145,000 cubic yards of gravel was being handled monthly.

PRODUCTION

Tables 1 to 7 show production by districts, and table 8 gives accurate compilations of the officially reported production of the region fro 1901 to 1935, inclusive. Estimates of production earlier than 1901 indicate that lode production was probably greater from 1863 to 1900 than from 1901 to 1935. Rough estimates of earlier production are included at the end of table 8; these estimates are undoubtedly lower than the actual production.

Virtually all of the base metals produced in the region have been byproducts of gold and silver production. The Mammoth mine has at times been considered a copper mine, and some mines in the Sheridan and Twin Bridges districts have produced ore in which lead was of prime importance. Nevertheless gold and silver have been, and will continue to be, the important metals of the region. The recorded base-metal production represents net smelter returns on concentrate shipments and on shipping ore that contained enough base metal for payment on it. The base-metal statistics therefore are not a true measure of the base-metal content of the ores.

(Mineral Hill, Sand Creek, Potosi, Mammoth, and South Boulder)

Year	Producing mines	Crude ore produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Total value including placer	Value, placer gold and silver
1901	1	40	150.01	400	---	---	$3,341	---
1902	13	1,775	2,201.79	1,151	21,000	---	46,986	---
1903	2	685	660.95	600	25,000	---	15,037	---
1904	7	1,487	3,444.64	4,019	---	---	73,538	---
1905	9	16,932	4,339.53	4,382	76,319	3,205	96,466	$179
1906	7	11,132	4,008.40	8,900	112,000	50,398	105,175	---
1907	9	6,924	2,966.79	4,750	7,491	28,590	70,579	---
1908	13	5,816	2,702.47	4,168	15,119	11,318	60,203	---
1909	14	7,485	4,334.45	3,900	1,140	9,800	92,952	---
1910	10	15,301	6,573.05	6,650	---	20,677	142,094	---
1911	11	15,370	4,055.76	5,083	8,022	8,544	87,963	---
1912	8	14,192	2,803.33	5,273	267	4,067	61,876	---
1913	9	7,431	1,750.45	2,096	4,409	3,303	38,157	---
1914	11	10,158	2,017.77	1,796	6,769	2,669	43,323	98
1915	6	10,101	4,040.33	2,927	---	3,194	85,564	---
1916	8	9,931	2,143.69	3,146	7,145	34,232	55,298	---
1917	7	5,550	644.45	1,290	2,744	28,971	22,530	---
1918	5	1,069	390.82	242	---	77	8,340	---
1919	1	24	85.72	275	---	532	2,179	---
1920	3	595	242.89	378	---	---	5,433	---
1921	4	310	123.31	113	---	---	2,662	8
1922	2	1,100	183.34	333	---	---	4,123	24
1923	2	1,310	260.21	228	---	---	5,566	75
1924	2	62	60.76	79	---	374	1,358	---
1925	3	17,055	3,114.48	16,732	---	169,620	100,080	---
1926	6	79	75.90	226	2,650	21	1,925	---
1927	1	18,444	5,768.96	13,783	---	172,290	149,640	---
1928	3	35,415	9,239.48	16,665	---	199,417	229,462	---
1929	3	31,721	8,659.22	12,955	1,079	115,199	206,250	---
1930	4	32,580	10,166.54	17,052	---	153,346	236,661	---
1931	8	12,090	3,485.37	10,962	297	83,956	82,879	---
1932	12	19,361	6,750.01	12,539	500	80,079	148,131	---
1933	11	31,893	6,133.96	11,203	---	67,750	165,041	23
1934	28	32,537	6,084.95	9,507	649	23,050	220,683	354
1935	25	29,820	6,652.80	9,408	---	36,458	242,636	441
1901-35	268	405,775	116,316.58	193,211	292,600	1,311,137	2,914,131	1,202

TABLE 2.--Lode production, Norris district, 1901-35

Year	Producing mines	Crude ore produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Total value including placer	Value, placer gold and silver
1901	8	1,835	2,341.01	2,100	---	---	$49,653	$1,000
1902	11	1,905	5,131.29	7,400	---	9,000	111,093	---
1903	3	95	105.02	---	---	---	2,171	---
1904	6	3,286	1,415.21	2,488	---	10,000	31,978	---
1905	13	10,431	6,242.55	23,341	25,298	7,609	145,659	326
1906	10	317	810.91	1,100	12,456	---	18,221	---
1907	9	200	214.88	450	---	260	4,791	67
1908	18	409	479.93	736	2,238	1,189	10,562	81
1909	18	3,805	1,089.16	1,575	---	1,069	23,473	---
1910	16	1,392	462.32	1,450	4,705	165	10,568	---
1911	22	524	551.91	4,149	1,533	864	13,785	---
1912	11	342	351.01	439	289	685	7,652	---
1913	17	241	445.92	520	1,273	32	9,593	---
1914	11	210	217.88	246	667	8	4,667	---
1915	16	214	457.00	2,286	170	1,794	10,928	---
1916	7	110	231.33	1,073	609	2,378	6,115	---
1917	14	122	292.57	1,449	---	1,806	7,735	---
1918	3	32	63.47	925	---	332	2,319	---
1919	10	96	131.58	1,817	547	328	4,845	---
1920	5	19	9.87	1,056	400	---	1,387	---
1921	9	4,889	2,800.43	5,017	133	---	62,913	---
1922	6	1,142	578.95	1,699	---	---	13,667	---
1923	8	30	33.67	900	557	68	1,483	---
1924	7	50	150.64	494	50	1,756	3,679	---
1925	8	51	155.72	686	---	669	3,790	439
1926	10	76	258.71	351	150	---	5,579	2,637
1927	8	38	92.01	55	---	229	1,963	419
1928	3	141	42.86	41	207	---	922	---
1929	6	63	68.21	30	79	34	1,437	---
1930	8	217	238.25	135	160	554	5,057	1,969
1931	22	735	1,150.74	1,014	108	3,439	24,399	5,499
1932	27	361	442.10	532	33	1,730	9,399	177
1933	21	519	3,186.19	1,257	3,514	3,406	82,227	65,367
1934	38	1,899	1,122.06	1,926	2,162	5,000	40,941	238
1935	38	2,902	3,847.20	3,392	31,125	2,362	138,531	---
1901-35	447	38,698	35,[illegible].56	[illegible]	88,463	56,76[illegible]	873,188	78,219

Year	Producing mines	Crude ore produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Total value
1901	--	--	--	--	--	--	--
1902	1	24	298.71	468	5,683	--	$6,656
1903	1	58	229.59	300	--	--	4,908
1904	1	30	114.02	169	721	--	2,486
1905	3	348	905.53	3,764	13,553	269	21,694
1906	3	220	689.73	1,775	3,070	--	15,640
1907	2	565	625.39	4,000	--	--	15,568
1908	2	257	348.93	967	--	151	7,746
1909	3	113	256.77	177	--	123	5,416
1910	1	269	147.78	100	--	--	3,109
1911	2	247	336.35	942	2,489	--	7,564
1912	3	130	435.57	1,101	622	200	9,742
1913	4	460	1,038.08	4,563	--	536	24,298
1914	4	1,378	3,698.17	10,763	51	--	82,402
1915	4	998	2,338.59	4,499	--	606	50,730
1916	3	141	314.27	1,743	--	--	7,654
1917	1	2	11.27	6	186	--	254
1918	1	14	65.98	55	--	--	1,419
1919	2	770	612.38	675	2,358	21	13,544
1920	1	1,600	1,309.85	1,689	3,100	--	29,166
1921	2	3,451	2,843.72	2,871	4,889	--	61,876
1922	2	2,148	1,932.34	2,054	4,782	--	42,262
1923	2	1,195	562.07	1,000	--	34	12,444
1924	5	201	169.07	712	--	--	3,972
1925	3	17	52.44	108	--	42	1,165
1926	2	28	102.70	242	3,375	--	2,544
1927	3	1,019	599.27	1,037	1,540	84	13,084
1928	--	--	--	--	--	--	--
1929	--	--	--	--	--	--	--
1930	2	8	30.67	96	380	8	691
1931	4	100	334.37	455	2,784	352	7,179
1932	6	222	396.72	752	533	524	8,462
1933	3	134	375.00	1,057	1,378	297	10,025
1934	7	1,138	999.80	3,383	12,811	125	37,614
1935	8	217	496.20	1,145	1,600	24	18,254
1901-35	91	17,502	22,671.33	52,668	65,905	3,396	529,570

TABLE 4. - Metal production, Virginia City District, 1901-35

Year	Producing mines		Crude ore produced, dry tons	Gold			
				Placer		Lode	
	Placer	Lode		Fine ounces	Value	Fine ounces	Value
1901	1	3	1,013	228.43	$4,722	400.11	$8,271
1902	6	4	2,639	12,340.17	255,094	2,717.42	56,174
1903	5	1	2,000	10,845.87	224,204	4,000.03	82,688
1904	5	2	17,475	12,640.00	261,292	5,004.49	103,452
1905	5	4	6,472	12,970.74	268,129	3,594.65	74,308
1906	3	6	5,629	18,482.25	382,062	3,408.89	70,468
1907	6	9	1,152	9,200.49	190,191	1,996.92	41,280
1908	6	12	1,736	19,892.72	411,219	1,466.15	30,308
1909	8	17	7,930	20,552.65	424,861	3,697.69	76,438
1910	7	17	12,622	22,433.81	463,748	6,795.72	140,480
1911	9	24	9,347	28,160.88	582,137	5,368.27	110,972
1912	9	30	2,856	33,275.37	687,863	1,909.41	39,471
1913	11	25	5,843	33,354.51	689,499	3,233.48	66,842
1914	5	24	12,620	40,416.25	835,478	4,941.46	102,149
1915	5	24	4,426	41,635.59	860,684	2,027.88	41,920
1916	3	14	908	31,154.81	644,027	420.67	8,696
1917	3	14	906	19,935.34	412,100	361.17	7,466
1918	3	10	1,867	16,195.81	334,797	768.34	15,883
1919	2	14	1,722	12,849.37	265,620	392.56	8,115
1920	2	9	459	12,367.02	255,649	221.46	4,578
1921	2	8	4,539	9,213.21	190,454	1,984.10	41,015
1922	4	8	13,190	1,817.40	37,569	1,961.51	40,548
1923	6	7	1,182	663.12	13,708	310.62	6,421
1924	5	12	1,146	235.25	4,863	423.96	8,764
1925	6	9	1,754	432.28	8,936	475.13	11,889
1926	2	10	673	46.15	954	326.05	6,740
1927	2	7	619	17.56	363	364.36	7,532
1928	3	4	93	130.66	2,701	52.97	1,095
1929	3	4	177	28.54	590	335.53	6,936
1930	3	6	358	19.93	412	336.69	6,960
1931	9	11	1,854	112.81	2,332	639.47	13,219
1932	8	12	1,941	107.20	2,216	703.37	14,540
1933	5	11	6,337	79.85	2,041	1,237.91	31,641
1934	38	15	10,280	272.76	9,533	2,287.44	79,946
1935	6	24	18,736	4,618.80	161,658	3,453.60	120,876
1901-35	206	411	162,501	426,727.60	8,891,706	67,719.48	1,488,081

TABLE 4. - Metal production, Virginia City District, 1901-35, Cont'd

Year	Silver				Lead		Copper		Total value
	Placer		Lode						
	Fine oz.	Value	Fine oz.	Value	Pounds	Value	Pounds	Value	
1901	—	—	1,210	$726	--	--	--	--	$13,719
1902	1,900	$1,007	59,179	31,365	--	--	--	--	343,640
1903	1,600	864	—	—	--	--	--	--	307,756
1904	1,269	736	98,750	57,275	—	—	--	—	422,755
1905	1,964	1,198	66,136	40,343	—	—	--	—	383,978
1906	2,750	1,870	87,900	59,772	88,158	$5,025	750	$147	519,344
1907	1,500	990	50,850	33,561	8,622	457	770	154	266,633
1908	3,200	1,696	10,900	5,777	191	8	917	121	449,129
1909	3,302	1,717	65,800	34,216	—	—	5,423	705	537,937
1910	2,439	1,317	92,824	50,125	1,204	53	5,142	653	656,376
1911	4,498	2,384	73,215	38,804	—	—	4,016	502	734,799
1912	5,086	3,128	20,870	12,835	--	--	2,436	402	743,699
1913	4,861	2,936	55,957	33,798	68	3	2,471	383	793,461
1914	6,139	3,395	149,839	82,861	—	—	2,436	324	1,024,207
1915	7,209	3,655	65,428	33,172	—	—	74	13	939,444
1916	4,863	3,200	17,231	11,338	4,087	282	699	172	667,715
1917	3,119	2,570	15,057	12,407	523	45	3,923	1,071	435,659
1918	2,600	2,600	16,704	16,704	169	12	243	60	370,056
1919	2,150	2,408	12,491	13,990	340	18	699	130	290,281
1920	1,989	2,168	7,789	8,490	250	20	299	55	270,960
1921	1,345	1,345	22,452	22,452	21,200	954	512	66	256,286
1922	381	381	27,468	27,468	9,218	507	4,385	592	107,065
1923	139	114	8,472	6,947	429	30	95	14	27,234
1924	39	26	4,782	3,204	150	12	84	11	16,880
1925	114	79	6,647	4,613	1,334	116	49	7	25,640
1926	8	5	3,718	2,320	1,300	104	57	8	10,131
1927	2	1	9,381	5,319	4,921	310	15	2	13,527
1928	19	11	665	389	879	51	—	—	4,247
1929	15	8	3,803	2,027	—	—	2,716	478	10,039
1930	3	1	4,787	1,843	1,760	88	1,277	166	9,470
1931	21	6	3,707	1,075	1,189	44	3,450	314	16,990
1932	21	6	2,326	656	267	8	[illegible]	251	17,677
1933	17	6	5,817	2,036	3,216	119	2,125	136	35,979
1934	48	31	10,333	[illegible]	13,243	490	[illegible]	304	96,984
1935	818	588	[illegible]	[illegible]	15,300	612	[illegible]	216	301,614
1901-35	65,428	42,447	[illegible]	632,252	178,018	9,368	55,449	7,457	11,121,311

TABLE 5. - Lode production, Sheridan district, 1901 - 35

Year	Producing mines	Crude ore, produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Zinc, pounds	Total value, including placer	Value, placer gold and silver
1901	--	--	--	--	--	--	--	--	--
1902	3	1,799	719.24	9,549	26,000	--	--	$20,995	--
1903	3	2,722	863.64	9,200	63,905	--	--	25,505	--
1904	10	10,741	2,707.09	17,774	171,163	1,297	--	75,656	$7,932
1905	10	6,941	2,135.71	10,500	78,936	1,000	--	54,420	2,638
1906	10	550	1,370.56	3,859	2,404	3,000	--	31,681	7,744
1907	7	86	236.82	953	6,113	--	--	6,882	4,163
1908	22	724	903.26	4,217	357	667	--	21,010	3,372
1909	19	441	731.86	3,342	2,116	1,062	--	17,096	2,515
1910	12	523	773.76	2,550	--	3,496	--	17,816	2,328
1911	17	1,095	871.91	4,336	19,778	4,080	--	21,722	2,728
1912	13	322	444.71	2,377	--	4,600	--	11,414	1,340
1913	18	1,944	429.57	6,023	124,932	4,497	--	18,712	2,164
1914	17	1,008	1,041.56	4,333	37,795	3,391	--	25,852	506
1915	25	1,067	1,384.54	3,947	32,128	5,446	--	33,085	1,848
1916	19	594	584.08	2,023	52,319	13,268	2,642	20,633	744
1917	13	283	316.47	1,591	23,023	469	--	9,961	1,484
1918	22	4,089	584.61	6,870	176,380	42,765	--	42,041	1,345
1919	13	1,511	700.18	10,167	23,151	25,844	--	31,895	18
1920	14	467	223.83	13,067	44,125	1,848	--	22,740	602
1921	12	764	472.96	3,933	1,778	233	--	13,820	668
1922	6	1,923	1,254.51	2,021	--	15	--	27,956	996
1923	11	1,137	587.03	3,139	3,886	--	--	14,981	963
1924	12	708	353.38	1,357	21,375	1,397	--	10,107	1,330
1925	16	1,899	369.44	6,180	83,310	63	106,513	27,278	777
1926	13	3,946	748.41	13,000	207,525	500	150,893	51,572	259
1927	9	1,403	532.85	2,767	35,349	84	--	14,822	507
1928	11	813	754.02	4,176	20,793	2,146	11,180	20,227	409
1929	10	3,194	448.53	6,753	100,381	12,216	4,182	21,624	1,798
1930	15	3,039	656.64	4,418	81,980	8,123	19,042	21,344	1,612
1931	16	3,187	1,100.24	1,376	--	1,451	--	23,275	2,710
1932	24	3,198	1,330.94	9,330	--	4,016	--	30,397	3,947
1933	40	1,382	830.71	2,140	3,486	1,844	--	22,229	3,235
1934	41	1,664	1,187.84	2,950	865	2,000	--	43,614	5,142
1935	34	1,469	1,324.00	4,821	150	843	--	49,881	4,964
1901-35	537	66,633	29,114.90	185,044	1,445,503	151,661	294,452	902,243	72,788

TABLE 6.—Lode production, Twin Bridges district, 1901-35
(Tidal Wave)

Year	Producing mines	Crude ore, produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Zinc, pounds	Total value, including placer	Value, placer gold and silver
1901	2	94	208.98	1,140	18,000	--	--	$5,821	--
1902	2	76	158.67	634	25,878	--	--	4,677	--
1903	1	48	.92	300	10,000	--	--	601	--
1904	1	21	41.02	138	8,000	--	--	1,272	--
1905	3	67	712.08	17,487	52,915	--	--	27,874	--
1906	11	634	721.03	5,475	76,263	3,750	--	23,710	$1,217
1907	7	184	428.85	2,059	55,642	--	--	13,173	1,221
1908	12	1,662	695.34	7,136	145,238	3,909	--	24,772	--
1909	17	488	818.51	9,931	155,953	877	--	28,904	--
1910	13	837	919.56	7,987	132,136	2,520	--	29,456	--
1911	22	400	596.85	6,415	146,689	2,208	--	22,615	92
1912	22	196	250.87	2,608	55,289	1,460	--	9,519	--
1913	16	154	292.04	1,715	9,909	4,303	--	8,176	--
1914	12	1,270	1,001.75	3,631	65,410	22,684	--	28,284	--
1915	21	1,003	1,810.14	4,702	86,915	3,960	--	44,581	190
1916	21	11,849	4,341.90	10,409	250,565	52,862	--	126,897	--
1917	27	7,151	2,487.25	10,801	331,861	14,791	--	92,894	--
1918	11	2,120	898.18	7,973	203,761	7,652	11,110	43,908	--
1919	10	247	282.03	4,808	112,151	3,823	--	17,870	--
1920	9	523	1,272.55	5,310	185,600	984	--	47,123	--
1921	12	764	2,046.46	3,018	35,578	1,682	--	47,140	--
1922	10	722	1,872.45	3,650	7,982	5,059	--	43,479	--
1923	13	296	387.92	2,389	96,614	1,000	--	16,888	19
1924	14	339	126.79	2,321	84,525	1,306	--	11,109	--
1925	14	256	143.19	3,036	141,379	1,571	10,763	18,408	--
1926	14	260	358.70	2,085	107,625	43	--	17,332	--
1927	12	190	807.96	2,679	34,079	--	--	20,368	--
1928	12	166	515.00	882	27,552	521	--	12,835	--
1929	6	62	56.21	364	7,270	301	--	1,867	--
1930	10	143	245.02	787	21,420	846	--	6,549	--
1931	15	302	561.44	803	26,081	725	--	12,870	62
1932	24	448	761.76	1,117	23,433	1,714	--	16,873	--
1933	20	850	702.66	840	12,514	1,328	--	18,802	--
1934	26	8,676	2,163.29	3,881	26,243	5,350	--	79,515	--
1935	29	4,878	1,880.20	4,526	21,350	2,880	--	70,153	49
1901-35	471	47,376	30,567.57	143,037	2,801,820	150,109	21,873	996,315	2,850

TABLE 7. - Lode production, Renova district, 1901 - 1935

Year	Producing mines	Crude ore produced, dry tons	Gold, fine ounces	Silver, fine ounces	Lead, pounds	Copper, pounds	Total value
1901	2	3,580	5,670.42	14,685	--	--	$126,029
1902	3	2,024	2,058.79	10,000	--	22,729	50,632
1903	--	--	--	--	--	--	--
1904	1	335	837.42	312	--	--	17,492
1905	5	593	788.61	841	21,000	6,955	18,887
1906	5	368	626.07	1,175	7,070	--	14,144
1907	4	175	238.73	800	1,830	--	5,560
1908	5	148	376.89	917	572	1,076	8,443
1909	2	117	86.98	325	--	1,223	2,126
1910	2	50	51.47	200	114	858	1,286
1911	2	145	226.25	751	--	1,568	5,271
1912	3	413	249.08	1,096	--	1,654	6,096
1913	2	121	138.79	255	--	884	3,160
1914	2	48	71.74	123	--	391	1,603
1915	2	130	329.48	357	--	583	7,094
1916	2	39	17.66	73	--	5,427	1,748
1917	3	75	34.25	494	10,500	934	2,273
1918	--	--	--	--	--	--	--
1919	--	--	--	--	--	--	--
1920	1	751	17.32	144	--	--	515
1921	2	1,278	1,168.16	4,640	436,244	17,992	50,740
1922	1	1,014	478.43	3,205	292,455	20,289	31,919
1923	3	375	273.80	600	72,357	11,000	12,834
1924	3	490	336.69	451	97,650	3,832	15,576
1925	--	--	--	--	--	--	--
1926	3	205	240.23	3,064	62,300	271	11,900
1927	1	21	.53	81	--	4,649	666
1928	4	35	39.38	46	--	2,736	1,235
1929	1	1	.92	--	--	17	22
1930	1	22	9.82	13	3,700	31	397
1931	--	--	--	--	--	--	--
1932	1	20	27.48	21	--	48	577
1933	3	62	54.07	103	--	344	1,440
1934	5	154	119.60	232	--	675	4,384
1935	5	2,438	2,105.20	30,624	--	36	95,696
1901-35	79	15,227	16,674.26	75,628	1,005,792	106,202	499,745

TABLE 8.- Summary of lode-production statistics, Tobacco Root Range

	Pony district	Norris district	Washington district	Virginia City district	Sheridan district	Twin Bridges district	Renova district	All districts
Gold, 1901 - 35:								
Ounces........	116,274.42	32,044.77	22,671.33	67,719.48	25,839.91	30,431.83	16,674.26	311,656
Value.........	$2,615,464	$736,570	$491,887	$1,488,081	$569,413	$690,324	$376,823	$6,968,562
Ounces per ton	0.29	0.83	1.30	0.41	0.39	0.64	1.10	0.41
Silver, 1901 - 35:								
Ounces........	193,209	71,677	52,668	1,107,064	184,457	143,000	75,628	1,827,703
Value.........	$103,984	$46,997	$34,076	$682,252	$122,236	$98,299	$51,814	$1,139,658
Ounces per ton	0.48	1.85	3.01	6.81	2.77	3.02	4.97	2.42
Lead, 1901 - 35:								
Pounds........	292,600	88,463	65,905	178,018	1,445,503	2,801,820	1,005,792	5,878,101
Value.........	$14,853	$4,021	$3,184	$9,368	$87,563	$173,999	$56,181	$349,169
Pounds per ton	0.72	2.28	3.76	1.09	22	59	66	7.80
Copper, 1901 - 35:								
Pounds........	1,311,137	56,766	3,396	55,449	151,661	150,109	106,202	1,834,720
Value.........	$178,628	$7,375	$423	$7,457	$28,605	$29,014	$14,927	$266,429
Pounds per ton	3.23	1.47	0.19	0.34	2.27	3.17	7.0	2.43
Zinc, 1901 - 35:								
Pounds........	....	....	....	....	294,452	21,873	....	316,325
Value.........	....	....	....	....	$21,638	$1,829	....	$23,467
Pounds per ton	....	....	....	....	4.42	0.46	....	0.42
Tons of ore, 1901 - 35.....	405,775	38,698	17,502	162,501	66,633	47,376	15,227	753,742
Average value per ton.......	$7.18	$20.54	$30.26	$13.46	$12.44	$20.97	$32.82	$11.60
Total value, 1901 - 35.....	$2,912,929	$794,963	$529,570	$2,187,158	$829,455	$993,465	$499,745	$8,747,285
Estimated value, 1863 - 1900[1/].	$2,600,000	$3,000,000	——	$1,000,000	——	——	$1,500,000	$8,100,000
Approximate total value...	$5,512,929	$3,794,963	——	$3,187,158	——	——	$1,999,745	$16,847,285

[1/] Winchell, A. N., Mining Districts of the Dillon Quadrangle, Mont., and Adjacent Areas: U. S. Geol. Survey Bull. 574, 1914, 191 pp.

GEOLOGY

General

The area is underlain by a complex series of pre-Cambrian rocks which have been subdivided into the Pony, Cherry Creek, and Belt series. The Pony and Cherry Creek series underlie the Belt series and are designated as pre-Beltian. Sedimentaries and extrusives of later age are found around the margins of the area but are not generally important from a mining standpoint. The lead veins and a few gold veins in the Tidal Wave district, however, do occur in rocks mapped as Paleozoic sedimentaries.

According to Tansley and Schafer[6] the Pony series is composed of gneiss and schist of both sedimentary and igneous origin; the Cherry Creek series is composed of a garnetiferous gneiss, schist, quartzite, and limestone. Most mines are associated with one or the other of these two series or with intrusive quartz monzonite of later age. The Belt series, composed of arkose, arkosic conglomerate, and quartzite occupies small areas in the northwestern part of the region, notably near Gold Hill.

The pre-Cambrian complex is intruded by a large mass of quartz monzonite, referred to by Tansley and Schafer[7] as the Tobacco Root batholith. It is of late Cretaceous or early Tertiary age and is probably an outlier of the Boulder batholith, which outcrops a short distance to the west. The main mass of the Tobacco Root batholith outcrops southwest of a line between Pony and Norris, in an area approximately 16 miles long by 4 to 8 miles wide. The Pony and Norris mining districts are on or close to the contact between the batholith and the pre-Cambrian gneisses. All mining districts except the Virginia City district are within 3 to 5 miles of the contact; many mines in these districts are closely associated with small, outlying stocks of quartz monzonite.

South of Virginia City is an intrusive stock, characterized by Winchell as quartz-monzonite aplite. The Easton-Pacific mine is within this stock, and the Marietta, High-Up, and other mines are closely associated with it. All other mines of the Virginia City district are within a few miles of the stock; most are between the stock and main outcrop of the Tobacco Root batholith.

There is evidence of a rough zonal distribution of minerals around the batholith. The highest ratio of silver to gold and most of the silver-bearing sulphides are found in the veins of the Virginia City, Sheridan, Tidal Wave, and Renova districts, which are farthest from the outcrop of the main body of the batholith and occupy the higher stratigraphic members. These districts, particularly the last three, have produced the most lead and zinc. On the other hand, the only important copper producer (the Mammoth mine) is very close to the batholith.

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[6] Tansley, Wilfred, and Schafer, Paul A., work cited in footnote 4.

[7] Tansley, Wilfred, and Schafer, Paul A., work cited in footnote 4.

It might therefore be assumed that the percentages of silver, lead, and zinc are some measure of distance from, or above, the main body of the batholith. There is also some evidence of a high percentage of sulphides, resulting in lower ratios of concentration, in the mines of the inner or lower zones and a higher percentage of free-milling gold in the veins of the upper or outer zones. This evidence is inconclusive because of the large amount of oxidized ore treated in the shallower mines of the outer zones.

As usual, the problem of zoning is complicated by numerous apparent individual reversals of form. There are also wide variations in mineralization within each district, most of which may, however, be explained by zoning within the district. There is some evidence that the lead deposits in the western part of the region were deposited a little later than the ores in the gold-silver veins. There is, of course, an overlapping from district to district. Nevertheless, the broader relations give strong evidence that some zoning has taken place within the range of deposition of the ore deposits of the region. In this connection it is noteworthy that the Pony district between 1901 and 1935 produced more than 400,000 tons of ore from about 30 producing mines or claims; on the other hand, approximately 150 mines or claims in the Sheridan-Twin Bridges districts produced only slightly more than 100,000 tons in the same period. Between these is the Virginia City district, which produced more than 160,000 tons from about 60 reporting properties. This may indicate progressive weakening and wider dispersion of fracturing at greater distances from a large intrusive.

The interior of the batholith is generally barren of ore deposits. The mines on Revenue Flats are within the batholith but in its narrowest part. The tungsten and silver veins of the Potosi Hot Springs district are near the middle of the main body of the batholith but have been inactive for many years; they were not visited by the author. According to Hart[8], some of them may have commercial value under favorable market conditions.

Fissure Veins

With a few exceptions, which will be mentioned later, ore deposits in the Tobacco Root region are quartz veins occupying fractures in gneiss or quartz monzonite. Dips are usually 30° to 60° and correspond broadly to the principal jointing of the region; in exceptional instances the vein may be nearly flat or nearly vertical.

Two types of fissure veins are often recognized. In one, the quartz occurs as lenses in strong, gouge-filled fissures; in the other, it occurs in tabular veins in clean-cut tension fractures. The first type produces strong ore bodies only in strong, wide, fissures; the width of the fissure appears to bear a fairly definite relation to the size of the ore bodies; oreshoots usually comprise a number of closely spaced quartz lenses which in strong fissures often swell rapidly to widths of 5 to 10 feet and pinch out as rapidly. The second type may produce strong, persistent veins in fractures of little apparent strength; the quartz, even in very narrow veins, may be remarkably uniform in width and value for considerable distances. Although there is no definite line of demarcation between these types, the distinction is important where definitely recognizable.

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[8] Hart, Lyman H., work cited in footnote 5.

In the Twin Bridges and Sheridan districts fissure veins are found in limestone. In fact, the veins in these districts, unless within or close to a monzonite intrusive, show a decided preference for the limestone beds of the Cherry Creek series. This preference may be caused by stronger fracturing of the limestones or by the replaceability of certain beds which permits the formation of large oreshoots along weak fractures. Some veins are localized along the plane of weakness between limestone and other members of the series.

Many veins in the Twin Bridges and Sheridan districts occupy bedding plane faults in limestone and a few, in other sedimentaries. The veins in limestone may or may not be accompanied by replacement of the wall rock. Oreshoots are frequently pipelike or very irregular; their strength appears to depend upon the strength of shearing, also, possibly, upon the coincidence, as a result of slipping, of a small anticlinal roll in the upper bed with a synclinal roll in the lower bed.

Replacements

The ore of the Boss Tweed, Clipper, and Atlantic Pacific mines in the Pony district are replacements along zones of fracturing. At the Boss Tweed and Clipper the replacements occur in gneiss; at the Atlantic and Pacific, in aplite.

At the Strawn mine in the Tidal Wave district (Belle Canyon) gold is disseminated through silicified limestone beds. Mineralizing solutions appear to have been introduced from nearly vertical fractures, but this has not been definitely proved.

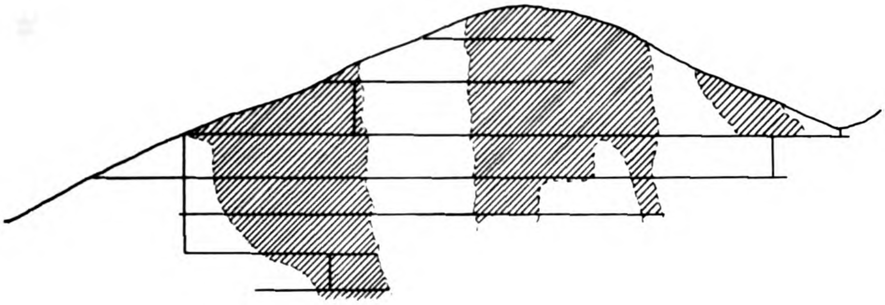
Shear Zones

The ore bodies in the Broadgauge-Tamarack mine in the Sheridan district are impregnations and replacements along a strong sheared and crushed zone in limestone.

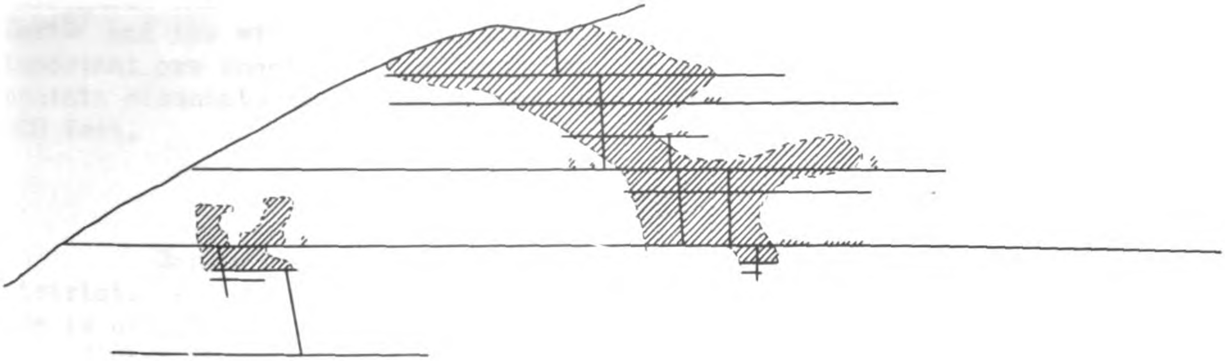
The Buckeye, Smuggler, and Corncracker mines in the Sheridan and Twin Bridges districts were inactive in 1936. According to Hart the ore consists of impregnations and veins of heavy sulphides along crushed and sheared zones in granite (monzonite) or gneiss.

Lodes

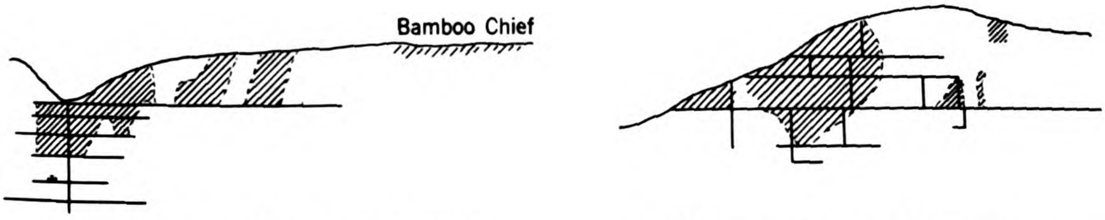
At the Galena mine in the Norris district the larger oreshoots



EASTON MINE, VIRGINIA CITY DISTRICT



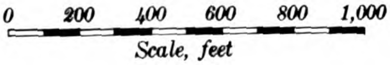
MAMMOTH MINE, PONY DISTRICT



ALAMEDA MINE, VIRGINIA CITY DISTRICT

PROSPECT MINE, VIRGINIA CITY DISTRICT

Figure 2.—Sketch illustrating ore shoots in some typical Tobacco Root quartz veins.



consist of a number of closely spaced quartz stringers between which the country rock (monzonite) is altered and mineralized to some extent.

A similar ore body had been crosscut at one place in the Pete and Joe mine in the Tidal Wave district. Past production from this mine had been derived, however, from simple fissure veins.

Oreshoots

Except for the Boss Tweed-Clipper, described on page 34, none of the more unusual types of ore deposits have been sufficiently developed to furnish reliable evidence of size or continuity.

Major oreshoots in several quartz veins have been fully developed, however. Commercial ore widths range from 1 to 10 feet; the average is 3 to 5 feet. There is a predominance of 3- to 5-foot widths throughout the region. Figure 2, based on sketches from mine maps by Hart[9] and the writer, illustrates the over-all size of some of the more important ore shoots so far developed. Many partly developed veins contain oreshoots that have an indicated strike length of 150 to 300 or 400 feet.

Ore Values

Table 8 gives the average metal content of the ores in each district. As might be expected the highest metal content per ton of ore is usually found in districts whose production has been chiefly from direct shipping ores and the lowest in districts whose production has been chiefly from milling ores. The relative accessibility of the districts has also influenced the average value of the output to some extent.

The author believes that a more nearly true measure of the average value of run-of-mine ore may be obtained by examining the production records of mines that have milled large tonnages of ore mined by nonselective methods. These records indicate a remarkable uniformity in the gold content of the ores throughout the region. If the Renova district is excepted the usual gold content of major oreshoots in the region is one-third to one-fourth ounce of gold per ton. The silver, lead, copper, and zinc contents vary considerably.

A few mines, however, have been important producers of high-grade gold ore. In this respect the Mayflower mine in the Renova district is in a class by itself. Other high-grade mines have been comparatively small.

Secondary Enrichment

The prevalent idea that Tobacco Root oreshoots are largely the result of secondary enrichment has caused some operators to hesitate to initiate exploration at depth. This idea, however, is not borne out by the history of mines that have gone below water level; their experience indicates that deeper exploration is justified in strongly mineralized veins.

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[9] Hart, Lyman H., work cited in footnote 5.

Most Tobacco Root ore has undoubtedly been mined from the zone of oxidation, for reasons already discussed. As stated in the preceding section, the average value of selectively mined ore from near the surface has been higher than that of run-of-mine ore from greater depths. Furthermore, some oxidized ores may assay higher than unoxidized ores owing to the removal of valueless constituents by leaching. There is, however, no definite zone of impoverishment or enrichment such as is found in districts where secondary enrichment has been important. High-grade ore exists at all horizons from grass roots to the greatest depths mined; nearly always it bears a definite relation to the intensity of primary mineralization, regardless of whether or not the ore is now oxidized.

The widespread occurrence of manganese oxides suggests the possibility of some downward migration of gold. It has not been proved, however, that downward migration has taken place extensively in this region, nor does field evidence support such a contention.

Ore at Depth

Figure 2 indicates that expectation of ore to a depth of at least the maximum strike length of the oreshoot is reasonable. Usually exploration has not been pushed vigorously below the first lean or barren zone encountered; in some instances ore is said to remain in the lowest levels.

Field evidence shows that commercial primary mineralization exists over a vertical range of at least 2,000 feet; it probably exists over a much greater range. Actual mine developments have not, however, proved the downward continuity of any particular vein to more than 800 feet.

TOPOGRAPHY

The Tobacco Root Mountains rise rather abruptly from the broad, gently rolling valleys of the Jefferson and Madison Rivers. These valleys are approximately 5,000 feet above sea level.

The northern half of the range is high and rugged. The summit of the highest peak is 10,600 feet above sea level. Nevertheless, it does not stand out conspicuously from the surrounding peaks, few of which are less than 9,500 feet high. In this part of the range the highest peaks are nearer the western flank, which rises steeply from a nearly level valley. Slopes on the eastern flank are more gradual; the main range is approached through several miles of foothills.

South of a line between Sheridan and McAllister the summits gradually become lower, finally forming a low saddle on the western side of which the town of Virginia City is located at an elevation of 5,880 feet. South of Virginia City there is a gradual rise to Mount Baldy, 9,500 feet high. Although the region south of Virginia City is known as the Gravelly Range, that part between Virginia City and Mount Baldy is geologically and economically a part of the Tobacco Root Mountains and is so considered in this paper.

ACCESSIBILITY

The region is reached by automobile from Butte (fig. 1) on U. S. Highway 10 (south), which passes within a few miles of the northern end of the range. Montana State Highway 1 borders the eastern flank; State Highway 41 has been completed (August 1936) down the western flank to within a few miles of Twin Bridges. These are all excellent, surfaced highways.

From Twin Bridges, through Sheridan, Ruby, and Virginia City, to Ennis, on State Highway 1, a graded dirt and gravel road completes the circuit of the range. Road distances are indicated on figure 1.

The northern end of the range is served by both the Chicago, Milwaukee & St. Paul Ry. and the Northern Pacific Ry. The latter also has a branch down the east flank of the range to Norris and a branch down the western flank to Alder. Railway shipping points are within relatively short hauling distance of the mining districts.

All mining districts, and nearly all mines, are served by mountain roads which are passable by trucks and passenger automobiles during the summer and fall months. Few mines are more than 10 miles from the highway. Most of the mountain roads are in fairly good condition, the others could be made so at a reasonable cost. There are few places where much heavy rock work would be required.

From November to May, inclusive, mountain travel is closed or uncertain. As snowfall is moderate except in the higher parts of the range, roads may frequently be kept open all winter at elevations under 7,000 or 7,500 feet. Roads on which there is no drifting may be kept open at reasonable expense to much higher altitudes.

CLIMATE

The climate is semiarid. Summer temperatures are warm but seldom extreme, and nights are usually cool; thundershowers are frequent in the higher mountains and occasional in the valleys.

The winters are cold, but snowfall is moderate except in the higher mountains where 4 to 7 feet of snow may be expected. The United States Weather Bureau reported a depth of 80 inches of snow in the Tobacco Root Mountains adjacent to Sheridan at the end of March 1936; at Sheridan the depth was 12 inches; the Weather Bureau report stated that this depth was above normal. Miners operating properties at elevations of about 7,000 feet reported a maximum depth of about 2 feet of snow on the level during recent years.

Climatic conditions in towns adjacent to the Tobacco Root Mountains are shown in tables 9, 10, and 11; the indicated statistics were supplied by the United States Weather Bureau.

TABLE 9 - Average precipitation in inches in towns adjacent to Tobacco Root Mountains

Elevation - feet	4,845	4,650	5,880
Station	Norris	Twin Bridges	Virginia City
Number of years observed	15	7	33
January	0.55	0.19	0.60
February	.58	.50	.54
March	.99	.36	1.03
April	1.44	1.20	1.21
May	3.80	1.86	2.70
June	2.78	1.60	2.16
July	1.23	.81	1.25
August	1.05	.38	1.09
September	1.93	.38	1.39
October	1.62	.10	.89
November	.74	.53	.89
December	.56	.50	.77
Year	17.27	8.41	14.52

TABLE 10 - Average snowfall in inches in towns adjacent to Tobacco Root Mountains

Station	Norris	Virginia City
Number of years observed	14	16
January	6.7	8.1
February	8.4	6.0
March	8.6	10.2
April	6.4	9.1
May	3.0	8.0
June	0	1.3
July	0	0
August	0	-
September	1.7	2.5
October	6.8	4.5
November	5.6	10.1
December	7.7	9.1
Year	54.9	68.9

TABLE 11. - Temperatures in towns adjacent to Tobacco Root Mountains

Station	Norris	Twin Bridges	Virginia City
Number of years observed	15	6	17
Mean maximum:			
January	33.9	34.0	30.6
July	82.0	83.0	80.2
Year	56.3	57.4	52.8
Mean minimum:			
January	16.4	8.9	11.9
July	53.2	44.1	51.1
Year	34.0	26.8	30.2
Highest:			
January	60	55	56
July	99	100	103
Year	99	100	103
Lowest:			
January	-32	-28	-27
July	33	31	26
Year	-32	-35	-36
Latest date 32° or lower in spring	May 4 to June 11	May 28 to July 14	May 19 to June 23
Earliest date 32° or lower in fall	Sept. 10 to Oct. 12	Aug. 17 to Sept. 12	Aug. 24 to Sept. 24

WATER

Mines situated on the larger streams or well back in the mountains can usually obtain ample water for milling. Most mines have to depend, at least partly, on mine water. Usually this is sufficient if tailings are thickened. The mine water is usually suitable for milling.

The maximum flow of water reported from any mine was 500 gallons per minute. This mine was not operating, and there is some doubt as to the accuracy of the figure. Other mines reported flows of less than 100 gallons per minute. Only two mines were operating stopes below the level of gravity drainage; each reported a flow of approximately 40 gallons per minute.

TIMBER

Distribution

Timber of commercial size grows only in especially favored areas. On the lower, outward-facing mountain slopes vegetation comprises chiefly grass and sage brush. Within the range, distribution of timber is governed by the presence or absence of permanent streams. At lower elevations, only the streams which extend far back into the mountains are permanent. These long streams are usually fed from small lakes in the glacial valleys of the high mountains where water is fairly abundant. Therefore, the commercial timber supply is generally limited to the valleys of the larger streams and the lower slopes adjacent to them. In such areas enough medium-size pine, fir, spruce, and poplar is present for most mining purposes. Nearly all the timbered areas are within the National forests (fig. 3).

Cost

Rough-sawed lumber cost (1936) \$22.00 to \$25.00 per 1,000 board feet at the mill. Probably special rates could be obtained on large orders. There are several small sawmills in the region.

Round timber, delivered to the mine, cost \$0.80 for a 16- to 20-foot piece 6 inches in diameter at the small end. Round lagging of the same length cost \$0.15 each.

Mines situated in timbered areas can cut their own timber at a much lower cost, but no definite figures are available. Much will depend on the abundance of timber near the mine. In the heavily timbered mountains of eastern Oregon several mines reported a cost of 1½ cents a linear foot for mine timber cut on their own claims. In the same region mines operating portable sawmills of 18,000-foot capacity reported costs of \$8.00 per 1,000 board feet when operating within a maximum skid distance of one-fourth mile.

LABOR AND WAGES

Proximity to the large mines of Butte and to other mining districts of southwestern Montana assures the Tobacco Root region of a fairly constant supply of experienced mine labor.

Wages are governed largely by the prevailing wages in Butte. Consequently, higher copper prices will be reflected in higher wage scales. In the summer of 1936 wage scales at Tobacco Root mines were nearly all within the following limits.

Muckers and general labor	\$4.00 to \$4.25
Miners	4.25 to 4.50
Blacksmiths	4.75 to 5.50
Hoistmen	4.25 to 4.75
Millmen	4.25 to 4.75
Shift bosses	4.75 to 5.00

POWER

Figure 3 shows the location of power lines in service in the summer of 1936. The industrial power rates of the Montana Power Co.,

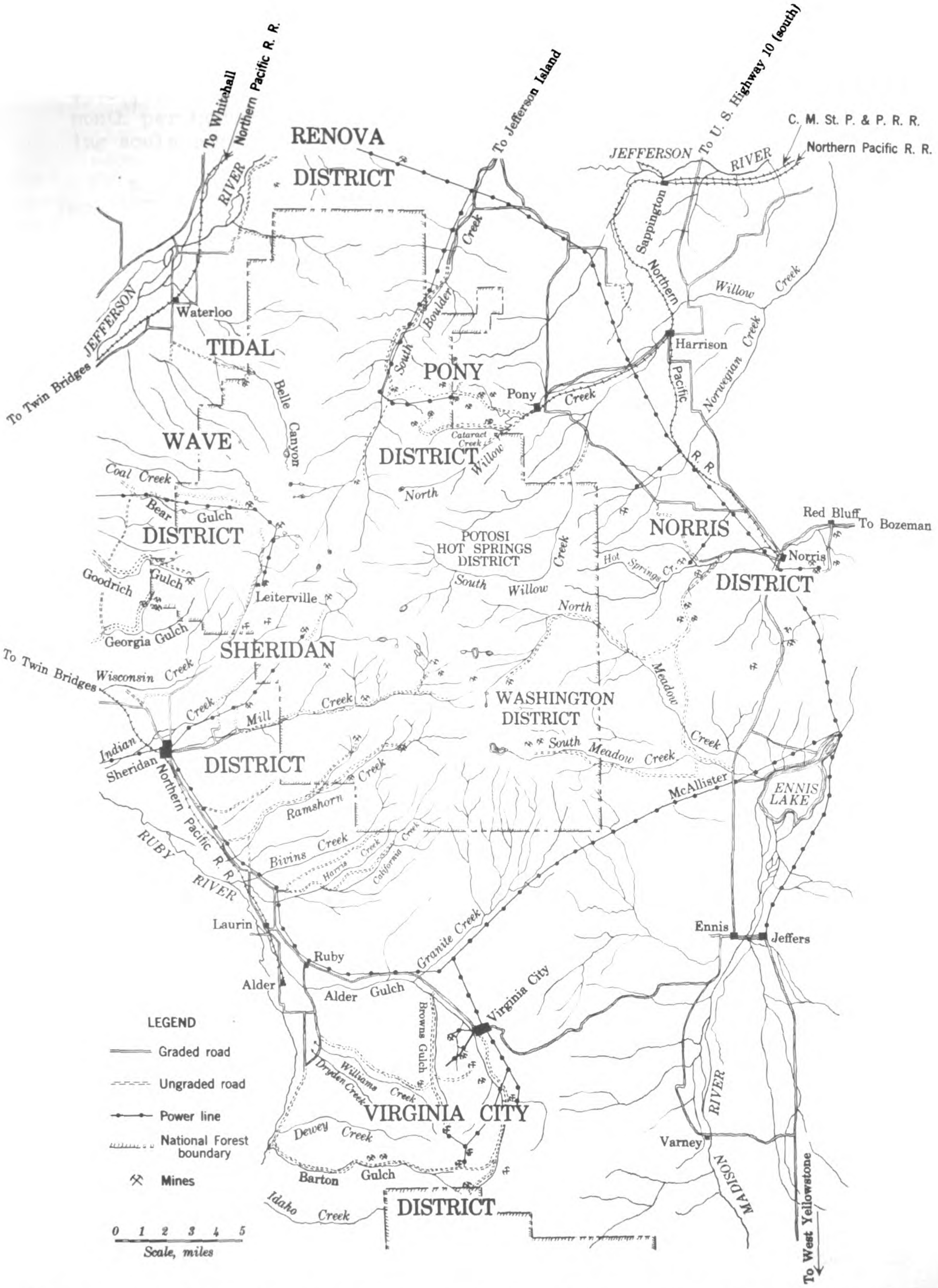

Figure 3.– Drainage map of Tobacco Root Mountains, showing location of mining districts and approximate location of roads and power lines.

Schedule G, under which most companies purchased power, are given below.

$1.00 for alternating current, $1.50 for direct current per month per horsepower of maximum demand, plus the following sliding scale rate per kilowatt-hour:

Hp.	Rate per kw-hr.	Hp.	Rate per kw-hr.
1	$0.028	100	$0.0087
2	.027	125	.0080
3	.026	150	.0074
5	.025	175	.0071
7½	.023	200	.0068
10	.021	300	.0061
15	.019	500	.0055
20	.017	750	.0051
25	.016	1,000	.0050
35	.014	2,000	.0048
50	.0116		
75	.0098		

If horsepower does not correspond exactly with any figure given in table, the next smaller number of horsepower is to be used in determining the kilowatt-hour rate.

TRUCKING COSTS

Trucking costs between mines and the main road vary considerably according to the elevation of the mine and the condition of the roads. The following examples illustrate charges on small shipments.

Mine	Approximate elevation	Railroad shipping point	Distance (miles)	Cost per ton	Cost per ton-mile
Jackpot.......	5,000	Norris........	5	$1.25	$0.25
Bozeman.......	8,500	Pony..........	8	2.00	.25
Revenue.......	5,400	Norris........	6	1.00	.17
Silver Bell...	6,000	Alder.........	6	1.00	.166
Homestake and Blackrock....	7,000	Alder.........	15	1.50	.10
Red Pine......	7,800	Sheridan......	9	3.00	.333
Lucky Strike..	9,000	Sheridan......	10	3.00	.30
Pete and Joe..	9,000	Twin Bridges..	15	2.50	.166

Loading and unloading charges are included in most of the above costs.

The usual trucking charge from mines in the region to the Washoe sampler at Butte is $5.00 a ton on irregular shipments. From mines on the eastern side of the mountains, truckers will haul to East Helena for $5.00 a ton; the charge from mines on the west side of the range to East Helena ranges from $5.00 to $6.00 a ton. The contract rate on regular shipments is about $0.50 a ton less. Although the distance to East Helena is considerably greater than that to Butte, the route to East Helena, via U. S. Highway 10 (north), follows the valley of the Missouri River, whereas the route to Butte crosses a mountain range at Pipestone Pass (elevation 6,418 feet). If the road from the mine to the main highway is relatively long or difficult, an additional charge is made. Thus one mine in the Washington district reports a trucking charge of $10.00 a ton from the mine to East Helena.

RAILROAD FREIGHT RATES

Freight rates on ores and concentrates, quoted (October 1936) by the two railroads serving the region, follow:

Chicago, Milwaukee & St. Paul Railway Co.

Value per ton not exceeding............	$10	$15	$25	$35	$50	$100	Over $100
To Butte (per ton) from:							
Piedmont.............	1.00	1.30	1.46	1.69	2.03	2.14	2.48
Jefferson Island......	1.00	1.30	1.46	1.69	2.03	2.14	2.48

Chicago, Milwaukee & St. Paul Railway Co.

Value per ton not exceeding............	$10	$15	$25	$35	$50	$100	Over $100
To East Helena (per ton) from:							
Piedmont.............	2.25	2.60	2.92	3.38	3.83	3.94	5.03
Jefferson Island......	2.25	2.76	2.92	3.38	4.06	4.28	5.03

Northern Pacific Railway Co.

Value per ton not exceeding.............	1/ $10	$15	$25	$35	$50	2/ $100
To Butte 3/ (per ton) from:						
Sappington.............	1.00	1.30	1.46	1.69	2.03	2.14
Harrison...............	1.00	1.40	1.58	1.80	2.14	2.36
Pony...................	1.00	1.40	1.58	1.80	2.14	2.36
Norris.................	1.00	1.40	1.58	1.80	2.14	2.36
Whitehall..............	1.00	1.30	1.46	1.69	2.03	2.14
Twin Bridges...........	1.00	1.60	1.80	2.03	2.36	2.59
Sheridan...............	1.00	1.60	1.80	2.03	2.36	2.59
Alder..................	1.00	1.60	1.80	2.03	2.36	2.59

1/ Temporary rate expires Dec. 31, 1936.

2/ For each $50 per ton (or fraction thereof) increase in value above $100 per ton add 20 percent to the rates provided herein for ore and concentrates of value of $100 per ton.

3/ Ores destined for the Anaconda smelter are received at the Washoe sampler in Butte. Switching to Washoe sampler, $3.60 per car extra.

Northern Pacific Railway Co.

Value per ton not exceeding	[1] $10	$15	$25	$35	$50	[2] $100
To East Helena (per ton) from:						
Sappington	1.00	1.40	1.58	1.80	2.25	2.36
Harrison	1.00	1.70	1.91	2.14	2.48	2.70
Pony	1.25	1.80	2.03	2.36	2.59	2.81
Norris	1.25	1.80	2.03	2.36	2.59	2.81
Whitehall	1.25	1.60	1.80	2.03	2.36	2.59
Twin Bridges	1.50	1.70	1.91	2.14	2.48	2.70
Sheridan	1.50	1.70	1.91	2.14	2.48	2.70
Alder	1.70	1.70	1.91	2.14	2.48	2.70

[1] Temporary rate expires Dec. 31, 1936.

[2] For each $50 per ton (or fraction thereof) increase in value above $100 per ton add 20 percent to the rates provided herein for ore and concentrates of value of $100 per ton.

SMELTING SCHEDULES

Smelter schedules in effect July 1936 at western custom smelters and a general discussion of smelting practice have been compiled by E. D. Gardner and Paul T. Allsman.[10] The following schedules for gold and silver ores quoted by the East Helena and Anaconda smelters have been abstracted from the compilation.

East Helena (lead smelter)

Payments:

Gold - minimum paid for 0.03 ounce per ton.

Ounces per ton	Per ounce
0.03 to 3	$31.81825
3 to 5	32.31825
5 to 10	32.6743
Over 10	33.0304

Silver - pay for 95 percent less 1 ounce per ton (present mint price, $0.77 per ounce)

Lead - no payment for less than 5 percent wet assay. Deduct from the wet lead assay 1.5 units (a unit is 20 pounds) and pay for 90 percent of the remaining lead at New York quotations, less 1.5 cents a pound.

Copper - no payment for less than 1 percent. Deduct from the wet assay 20 pounds and pay for 100 percent of the remaining copper at current quotations less 6 cents per pound.

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[10] Gardner, E. D., and Allsman, Paul T., Open Schedules for Gold and Silver Ores and Concentrates at Western Custom Smelters: Inf. Circ. 6926, Bureau of Mines, 1936, 25 pp.

Anaconda (copper smelter)

Payments:

Gold - Minimum paid for 0.01 ounce per ton. All classes of ore, $31.81825 per ounce.

Silver - if 1 ounce per ton or over, pay for 95 percent at current price less 2 cents an ounce. Minimum deduction 1 ounce per ton.

Copper - deduct 10 pounds per ton; pay for the remainder at 90 percent of current quotations, less $0.025 (2½ cents) per pound.

Lead - none.

Charges:

Treatment charge -

Base charge $4.00 per ton. Add 10 percent of gross value of metals in excess of $15.00 per ton.

Add $0.025 (2½ cents) for each unit of silica in excess of alumina.

Maximum charge not to exceed $5.50 per ton.

Zinc - none.

Arsenic - none.

Antimony - none.

Bismuth - none.

Iron - no credit.

Charges and deductions:

Treatment charges -

Gross value of ore per ton	Per ton
0 to $30	$6.00
30 to 40	5.50
Over 40	5.00

Above charges are on siliceous ores.

On ores and concentrates containing an excess of iron there is a flat charge of $5.00 per ton.

Deductions

Insoluble - none.

Zinc - allow 5 units free; charge for excess at $0.30 per unit; fractions in proportion.

Arsenic - allow 2 units free; charge for excess at $0.50 per unit; fractions in proportion.

Antimony - allow 1 unit free; charge for excess at $2.00 per unit; fractions in proportion.

Bismuth - 0.1 percent of the lead content by wet assay free; excess charged for at $0.50 per pound; fractions in proportion.

Sulphur - none.

Moisture - none.

LEASING

There always has been much small-scale leasing in the region, particularly in periods of general unemployment. Accessibility of the mines and the widespread occurrence of rich ore at grass roots or in

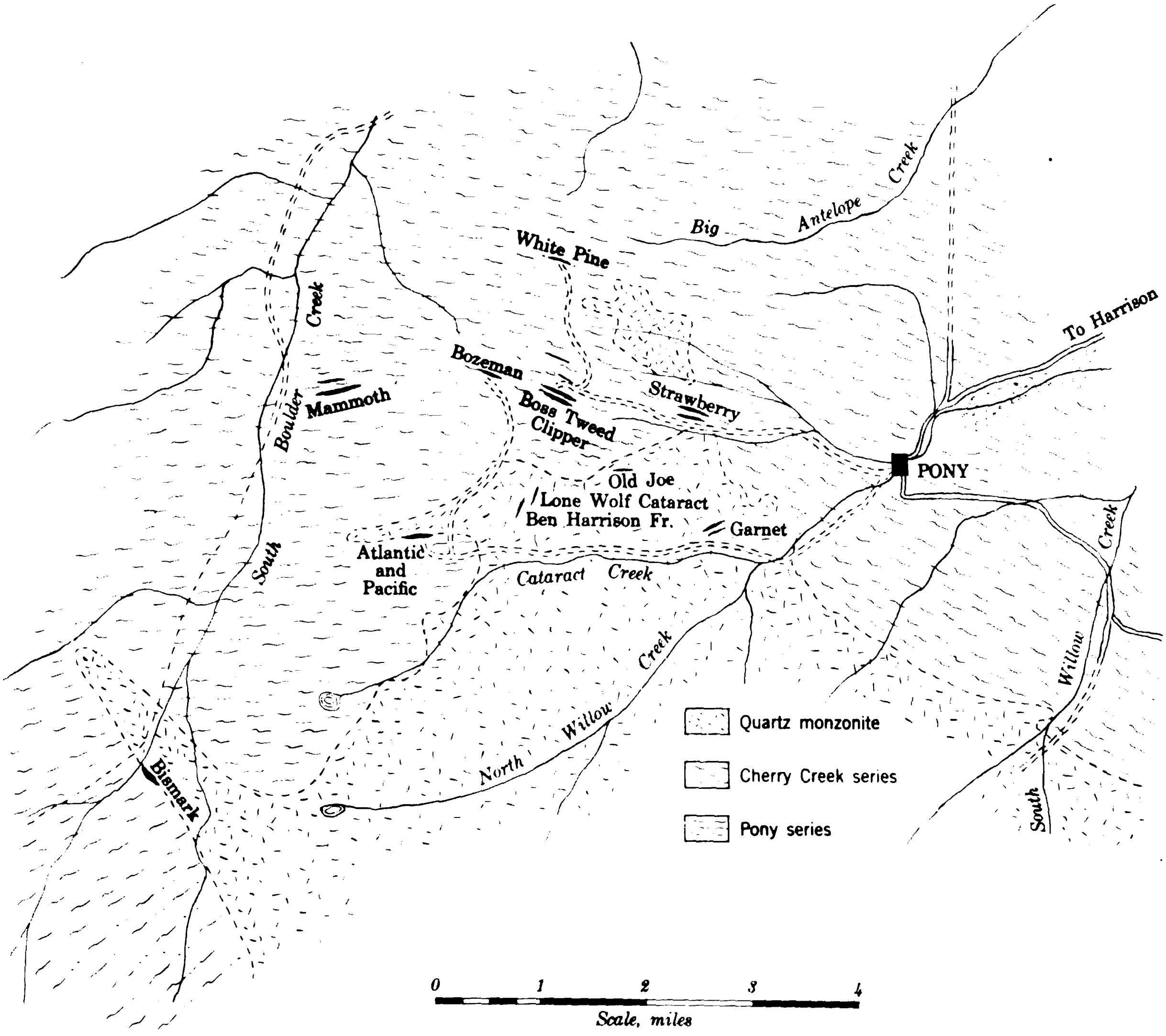

Figure 4.—Geological sketch, Pony district (after Tansley, Schafer, and Hart).

partly developed mines has enabled leasers to make fair wages with more than usual consistency.

Leases are generally granted on a straight 15-percent royalty basis. If the mine owner supplies equipment and power the royalty may be 25 percent or more.

MINES AND MILLS

General

The following brief descriptions of mines and mills include nearly every property at which there was notable activity in the midsummer of 1936. A few properties were missed because of relative inaccessibility coupled with adverse weather conditions at the time of visit. A few inactive properties which it seemed desirable to include have been mentioned.

No attempt has been made to describe every property in the region. Some production has been reported from more than 300 mines or claims; many not mentioned herein have been important producers.

Descriptions of individual mines are necessarily brief and incomplete. The purpose has been to present a broad view of ore occurrences, operating conditions, and mining and milling methods throughout the region. It is believed that the following descriptions are representative of present-day activities.

Pony District

The Pony district,(fig. 4) including the Mammoth mine, has been the largest producer of lode gold in the Tobacco Root region. Although it contains comparatively few small prospects, several of the largest mines of the region are in this district.

In the summer of 1936 the Boss Tweed and the Mammoth together produced about 150 tons of ore per day. Other small operations produced about 60 tons a month. The completion of the Atlantic-Pacific mill was expected to increase production another 150 tons per day.

Except for the Mammoth mine most mines of the district are within 3 or 4 miles of Pony. Truck hauls over mountain roads are therefore comparatively short. Beyond the Garnet and Strawberry mines transportation is handicapped by steep grades. Fortunately, however, most mines are below the level of heavy snows. Winter transportation may be maintained with comparative ease as far as the Boss Tweed or Ben Harrison Fraction.

Water and timber are abundant on the South Boulder side of the ridge but are scarce on the Pony side.

Mammoth

The largest individual producer in the Tobacco Root region is the Mammoth mine on South Boulder Creek, 16 miles by road south of the town of Jefferson Island. In the early days this mine produced considerable ore from shallow workings. In 1926 the Liberty Montana Mines Corporation spent over $50,000 for equipment and development work. Except for comparatively short periods this company has maintained production at 1,000 to 3,000 tons a month since that date. The total production from 1905 to 1935, inclusive, has been 53,377 ounces of gold, 113,938 ounces of silver, and 1,088,111 pounds of copper from 214,149 tons of ore; most of this was produced since 1924. For several years production has been at the rate of about 50 tons per day. Edward Deschamp is president and general manager.

Although accessible by road from Jefferson Island only, the Mammoth mine should be considered part of the Mineral Hill or Pony district. The Mammoth fissures are undoubtedly in a continuation of the zone of fracturing in which are the Clipper, Boss Tweed, Strawberry, and other important mines of the Pony district.

The Mammoth mine camp is in the valley of South Boulder Creek, at an elevation of about 6,000 feet. The road from Jefferson Island follows the creek, on an easy grade, for the entire distance. During the heaviest snowfall, from November to May, there is usually not more than 2 feet of snow at the camp, therefore concentrates can usually be trucked throughout the year.

Development. - The mine is opened by an adit tunnel at an elevation of about 6,500 feet. The mill is on the steep mountainside just below the adit. All supplies for mine and mill are hoisted on a surface tram from the valley bottom.

Air compressor. - A considerable part of the compressed air for mining is supplied by two Sullivan compressors having a combined capacity of about 2,150 cubic feet of air per minute. These are driven directly by Pelton-type water wheels operated under a 285-foot head. The storage dam was partly destroyed several years ago, and it is now necessary to supplement the water power by electric power purchased from the Montana Power Co.

The mill is driven entirely by purchased power.

Mining. - Mammoth ore bodies are more or less lenticular bodies of quartz in a strong fissure in the Pony gneiss. This fissure strikes easterly and dips about 60° to the south. The width of the ore averages about 7 feet but reaches 20 feet. Mineralization is chiefly auriferous pyrite and chalcopyrite, with some galena and sphalerite.

The oreshoots usually comprise numerous closely spaced lenses rather than a continuous tabular vein. In the past much had been overlooked by a failure to push development openings through the lean area between the lenses. Much of the more recent production has been obtained from areas within the old oreshoots which had been left as nonproductive in earlier years. To go through the old stopes after this ore was necessarily more expensive than stoping virgin ground.

Because of the approaching exhaustion of the older known oreshoots the main adit was being driven eastward. Some ore had been encountered, and it was believed that another major oreshoot would be opened up. Exploration work was also being done on parallel veins.

Virtually all ore is stoped by shrinkage methods. In high-grade ore the stopes are silled out on the drifts. In low-grade ore pillars may be left above the drifts. Chutes are built 10 to 20 feet apart.

When the mine was visited, nine stoper machine shifts and two drifter machine shifts were employed per 24 hours, mostly on development work. There were 30 men employed underground.

Most of the ore was being trammed about 4,000 feet from the working face to the mill. One horse and driver trammed 50 tons per shift in trains of eight $\frac{3}{4}$-ton cars.

Milling. - Mine ore was dumped into a 150-ton coarse-ore bin. From this bin it passed to a 12- by 18-inch jaw crusher which reduced it to 1- to $1\frac{1}{2}$-inch size.

An 18-inch belt conveyor carried it to the fine-ore bin, from the bottom of which another conveyor carried it to the feed scoop of a $4\frac{1}{2}$- by 6-foot Marcy-type ball mill turning at 28 r. p. m.

The ball mill operated in closed circuit with a Dorr duplex classifier. Between the mill and the classifier a Denver Sub-A unit flotation cell was placed which recovered about 60 percent of the total values.

Overflow from the Dorr classifier, at about 60 percent through 200-mesh, passed to a K & K flotation machine, the froth from which passed to a K & K cleaner.

Tails from the cleaner cell returned to the ball-mill feed. Tails from the rougher machines went to two Wilfley tables which made a final tail, a finished concentrate, and a middling that was returned to the ball-mill circuit.

All concentrate went to a Dorr thickener, thence to a 4-foot Oliver filter.

Concentrates were trucked in 4- to $4\frac{1}{2}$-ton loads to the railroad at Jefferson Island and thence shipped by rail to the Anaconda smelter.

Flotation reagents added to the ball mill comprised pine oil, 6 cc per minute, sodium xanthate, 12 cc per minute, and sodium sulphide, 20 cc per minute.

Recovery was about 92 percent on heads containing 0.26 ounce of gold per ton. In recent years the ratio of concentration has been about 10 : 1. Gold and silver is present in the ratio of about 2 ounces of gold to 3 ounces of silver. Concentrates assay 1 to 6 percent copper. Lead and zinc values are negligible.

Costs. - As already indicated, costs were high because of the large amount of development and exploration; however, it was not considered feasible to keep a separate account of development costs. Total costs for mining and milling 13,530 tons in 1935 were as follows:

	Per ton	
Mining (including exploration and development):		
Labor and supervision	$2.82	
Supplies and direct	1.31	
Power	.26	
Indirect	.53	
	4.92	$4.92
Milling:		
Labor	0.56	
Supplies and direct	.35	
Power	.40	
Indirect	.37	
	1.68	1.68
Transportation (trucking):		
Labor	0.07	
Trucks	.08	
	0.15	.15
Total operating		6.75

A comparison with costs for 1933 when relatively less development was done shows that milling and transportation in 1933 were virtually the same as in 1935 but that mining costs were only $3.93 per ton in 1933. Almost all the difference is in labor and supplies.

Strawberry

The Strawberry-Keystone group comprises six patented claims owned by the Elling Estate of Virginia City, Mont. The mine is 3.3 miles from Pony and is at an elevation of 7,000 feet; it was under lease to David Box of Pony.

Two veins known as the Strawberry and the Keystone are developed on the property. They converge to the east at about a 20° angle and diverge at depth. The Strawberry dips 50° to 60° north; the Keystone dips south at about the same angle. Both are quartz veins occupying strong fissures in gneiss. Where productive, the quartz is strongly

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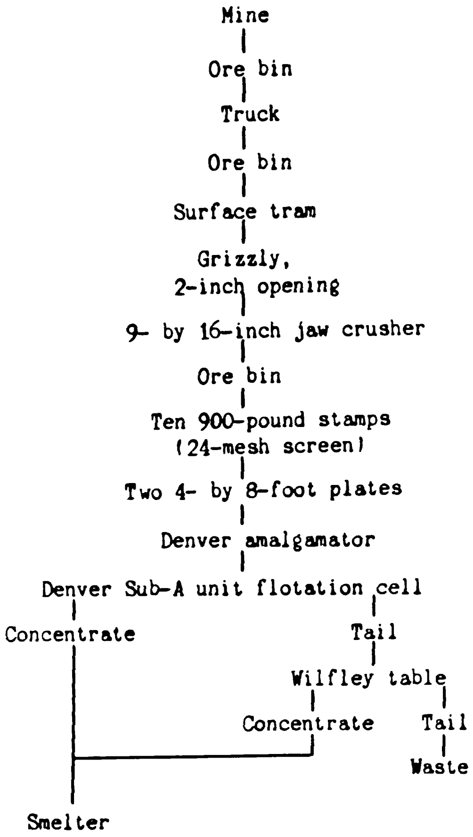

Figure 5.- Flow sheet, Strawberry mill.

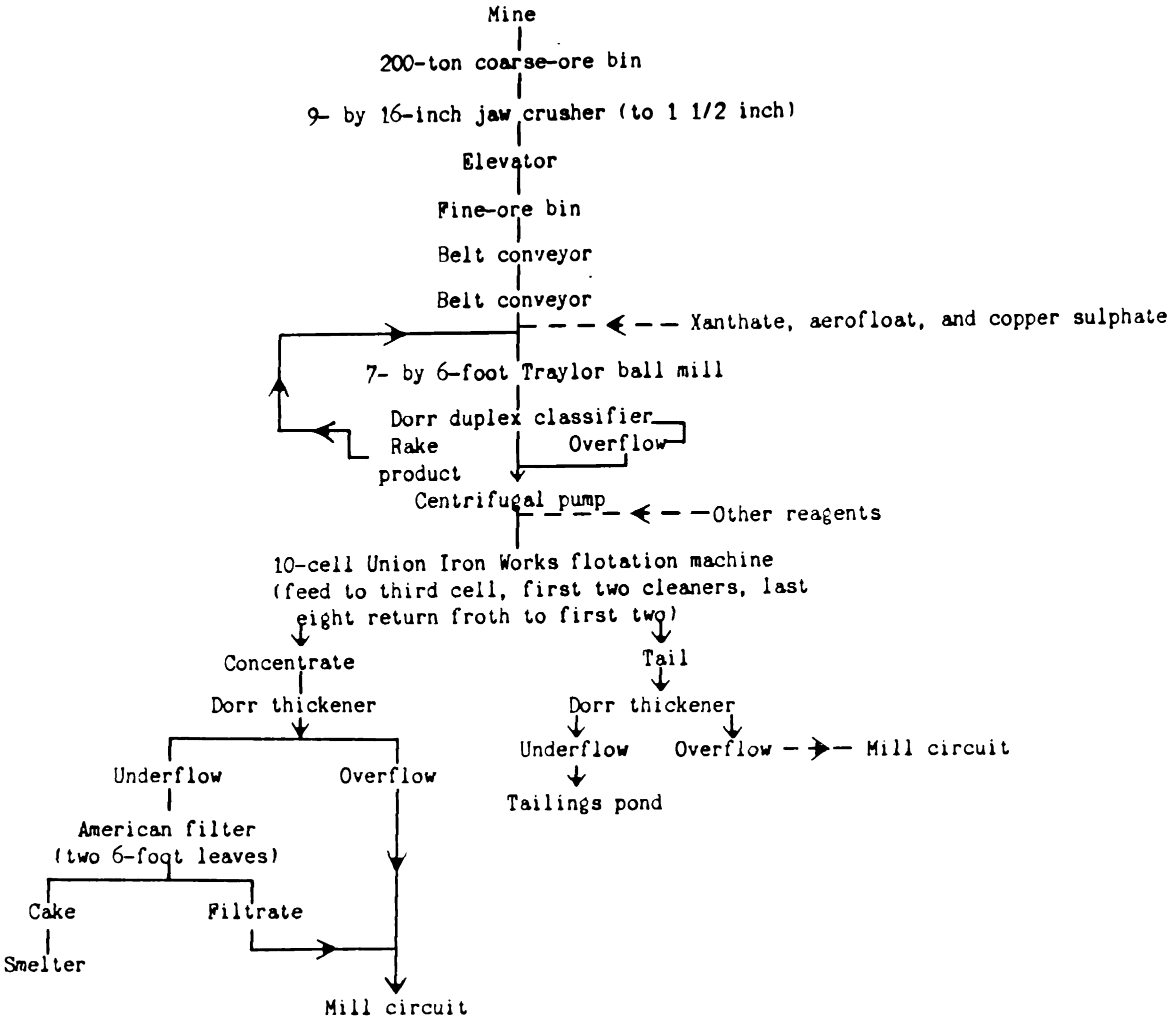

Figure 6.- Flow sheet, Boss Tweed mill.

mineralized with iron sulphides, which occur both as disseminations and as small stringers within the vein. Values are in direct proportion to the quantity of sulphides.

The mine is opened by an adit crosscut which intersects the Keystone vein 580 feet from the portal and at 1,000 feet cuts the Strawberry vein. About 250 feet of drifting had been done on the Strawberry and about 600 feet on the Keystone, much of which was caved. It is said that the Keystone in earlier years produced about $150,000 from the few hundred feet of backs between the adit level and the surface.

When the mine was visited mining was confined to shallow workings on the Strawberry vein. These were some distance west and above the crosscut. Here the vein had been opened for several hundred feet, and a stope 100 feet long was being worked. The drift did not expose the full width of the quartz but, where opened in the stope, the vein was 15 feet wide, measured horizontally, and well-mineralized throughout.

Mining. - The operators were mining selectively by following seams of heavy sulphides. Stopes were mined 5 feet wide by open-stope overhand methods; the high-grade sulphides were sorted and sacked for shipment, and the lower-grade ore was sent to the mill. It was said that the milling ore, after sorting, averaged $5 a ton. The ground stood well, requiring only an occasional stull support.

Machine drills were used. In 60 shifts two men mined and sorted 300 tons of ore.

Milling. - The mill was a half mile from the mine; the ore was trucked from the mine bunker to an outside mill bunker, then transferred in small cars to the crusher. Two men with a 3-ton truck handled about 30 tons in an 8-hour day.

Mine ore was dumped on a 2-inch grizzly (fig. 5), the oversize from which went to a 9- by 16-inch jaw crusher, thence to an ore bin. Ore was fed from the bin by Challenge feeders to 10 900-pound stamps, dropping 5 inches. The drop was allowed to increase to 7½ inches before resetting.

The stamp batteries discharged through 24-mesh screens to two 4- by 8-foot amalgam plates, thence to a Denver amalgamator, followed by a Denver Sub-A unit flotation cell. Amyl xanthate, aerofloat, and Barrett No. 4 were added to the cell. This made a finished concentrate assaying 1.8 ounces of gold per ton.

Flotation tails went to a Wilfley table which made a 1.30-ounce concentrate and a final tail.

A total of 35 hp. was required for milling; 20 hp. for the stamps; and 15 hp. for the crusher, flotation cell, and table. This power was furnished by a small hydroelectric plant.

Recovery was 81 percent. On oxidized ore 40 percent was recovered on the plates alone. The plate recovery on sulphide ore had not been determined. Mill capacity was about 1½ tons per hour.

Boss Tweed-Clipper

The Boss Tweed-Clipper group of claims has been the largest and one of the most consistent producers in the Tobacco Root region. It is located at the head of Pony Creek, at an altitude of 7,000 to 8,000 feet. The camp is reached from the town of Pony by 4 miles of dirt road, the last mile of which is steep mountain grade.

The Boss Tweed and Clipper are separate mines, geologically similar, which lie parallel and about 600 feet apart. Both differ from other Tobacco Root mines in that the ore consists of fractured, silicified, and mineralized gneiss. The ore is bounded on the foot and hanging walls by premineral faults, between which the gneiss has been so fractured as to admit the mineralizing solutions. Although the entire area between the faults is mineralized to some extent the commercial ore occurs in shoots that appear to be localized by the intensity and character of the fracturing. Mineralization is chiefly auriferous pyrite and free gold.

The faults bounding the Clipper ore zone are 10 to 40 feet apart, strike N. 60° W., and dip about 40° to the southwest. The mineralized zone has been developed for about 1,200 feet along the strike and about 600 feet on the dip. During the late nineties this mine is said to have produced about $1,500,000 from two oreshoots, one of which was 6 to 30 feet aide and extended from surface to the 600-foot level. The ore averaged about $10 a ton in gold and silver.

Production in later years has come principally from the Boss Tweed. In this mine the hanging-wall fault strikes N. 60° W. and dips about 45° southwest. The footwall fault is not continuous but is composed of a number of segments which differ slightly in strike and dip. In general, the foot and hanging walls diverge to the southeast and appear to be diverging downward; they are from 10 to 160 feet apart; the mineralized area extends 1,000 to 1,500 feet along the strike.

The first systematic development of the Boss Tweed is said to have been done by the Indian Mining Co. between 1900 and 1904. Adit levels were driven at 300, 400, 500, 600, and 700 feet; a 100-foot winze was sunk and the 800-foot level driven. During this period the company is said to have obtained $220,000 from 4,400 tons of ore.

Since then no aggressive development program has been undertaken. Nevertheless the property has been operated more or less steadily by leasers and, more recently, by a Japanese-controlled organization known as the Pacific Gold Mining Co. In the early summer of 1936 this company was mining and milling nearly 100 tons of ore per day.

From 1904 to 1935 the Boss Tweed mine produced 44,223 ounces of gold, 49,748 ounces of silver, and 57,090 pounds of copper from 171,415 tons of ore. The average ratio of concentration in this period was 17 to 1.

Two principal oreshoots, known as the east and west shoots, have been developed. Stopes 200 to 560 feet long and 10 to 20 feet wide have been worked on the 300-, 400-, 600-, and 700-foot levels. A stope said to be 30 feet long by 90 feet wide has been worked between the 700- and 800-foot levels. The oreshoots are irregular in shape and have no well-defined walls; stope limits are to some extent determined by the cost of mining. Therefore, the stoped ground does not necessarily indicate the maximum limits of the oreshoots.

Surface plant. - When visited in June 1936 the Boss Tweed was equipped with a 100-ton flotation mill, a 14- by 12-inch - 14- by 10-inch two-stage compressor, shops, bunkhouse, cookhouse, and office. Power was purchased from the Montana Power Co.

Mining. - All stoping was done by shrinkage methods; the walls stood well, and no stope timbering was required. Stope drilling was done with mounted drifters, two men to a machine. The foreman stated that four machine shifts per day could supply the mill with ore and keep the stopes filled. Detailed mine records over a long period were not available, but the following labor and supply distribution for 2 days (4 shifts) of operation was supplied by the mine foreman:

			Cost per ton (against 96.5 tons per day)	
Mining	man shifts	17	$0.375	
Timbering	do.	6	.132	
Mucking	do.	6	.132	
Tramming	do.	9	.200	
Blacksmith	do.	2	.049	
Carpenter-blacksmith helper	do.	2	.047	
Foreman	do.	2	.062	
Total mine labor	do.	44	.997	$0.997
Detonators		48	.003	
Fuse	feet	357	.001	
Powder	sticks	347	.167	
Posts		7	.019	
Caps		2		
Girts		6		
Total supplies			.190	.190
Mine labor and supplies				1.187
Cars ore trammed		247		
Cars waste trammed		20		

The above indicates a production of 4.6 tons per man shift or 24 tons per machine shift.

Milling. - The mill flow sheet is shown in figure 6. The following metallurgical data are for a 6-month period:

Days operated..........................	170
Total ore concentrated............tons	13,600
Average per day...............do.	80
Concentrates shipped...............do.	569.7
Net value concentrate.....per ton	$89.57
Head assay (gold at $35 ounce)...do...	4.86
Tail assay.......................do...	0.72
Indicated extraction......percent	85
Reagents used:	
Ethyl xanthate......pound per ton	0.278
Pine oil................do......	.52
Aerofloat...............do......	.26
Copper sulphate..........do......	.22
Soda ash..........................	A little

Smelter analysis of a typical concentrate shipment was as follows:

Gold.........ounces per ton	2.72
Silver.............do......	3.95
Copper..............percent	.05
Iron..................do...	35.1
Arsenic...............do...	.22
Antimony..............do...	.01
Bismuth...............do...	.03
Insoluble.............do...	18.8

Milling costs in dollars per ton were as follows:

Operation	Labor	Repair and maintenance	Supply and miscellaneous	Power	Reagents	Total
Crushing and grinding	0.157	0.101	0.135	0.30	--	0.693
Flotation............	.104	--	--	--	0.084	.188
Tailing disposal.....	.109	--	--	.01	--	.119
Water................	.042	.007	.002	.124	--	.175
Total............	.412	.108	.137	.434	.084	1.175

Concentrates were trucked to Helena for $4.50 per ton; about 4½ tons comprised a truckload. Mill labor was Japanese and was paid $3.00 per shift; mine labor was white and was paid $4.25 per shift.

White Pine

The White Pine and Pony claims, about 1 mile north of the Boss Tweed and 4.3 miles by road from Pony, were being worked under lease by A. R. Berg and H. E. Marshall. The mine is at an elevation of about 8,500 feet.

The oreshoot, which resembles a saddle reef, is formed at the intersection of two opposite-dipping fractures which terminate against each other. The intersection pitches about 45°. The vein, where mined, averaged about 8 inches in width and carried high gold values. In a little over a year, three men had produced 45 tons of shipping ore by hand methods.

The oreshoot had been mined to the surface, but the controling structure had not been explored below the adit level.

Garnet

The Garnet mine on Cataract Creek 2½ miles from Pony was under lease and bond to Hicks and Hansen of Pony; it was being operated on a sublease by Leonard Stone and associates.

Production has come from two fissure veins in granite. These veins, known respectively as the Galena and 149 vein, strike about N. 60° E. and dip southeast 40° to 60°. The veins are about 1,100 feet apart and are developed by a crosscut adit, 500 feet of drifting on the Galena vein, and about 300 feet on the 149 vein.

The Galena vein comprises a high-grade streak of heavy sulphides in the main fissure, and a hanging-wall zone of mineralized quartz monzonite which, according to Winchell,[11] formed ore bodies 5 to 20 feet wide.

This vein is said to have produced about 175,000 tons of $4 ore between 1898 and 1905. The stopes and drifts are now caved. Two feet of heavy sulphides were visible in the bottom of the drift at its intersection with the crosscut.

The mine was formerly equipped with a 20-stamp mill, plates, and vanners driven by waterpower. The equipment is still on the property but is in poor repair.

The leasers are now working on the 149 vein which, where opened, has a maximum width of about 8 inches of heavy sulphides. The first shipment of 5 tons was produced by two men using a machine drill in 10 days. This shipment assayed as follows:

Gold		$39.00
Silver	ounces	2.6
Lead	percent	5.1
Copper	do...	.63
Zinc	do...	.55

Assays up to $150 in gold had been obtained.

11/ Winchell, A. N., Mining Districts of the Dillon Quadrangle, Mont., and Adjacent Areas: Geol. Survey Bull. 574, 1914, 191 pp.

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Atlantic and Pacific

The Atlantic and Pacific claims are 6 miles up Cataract Creek from Pony at an elevation of 8,000 feet. The ore body comprises a fractured, silicified, and mineralized zone in a large aplite dike on the granite-gneiss contact. Mineralization was chiefly auriferous pyrite.

The mine was not working when visited, but considerable surface stripping had just been completed; preparations were being made to erect a 150-ton flotation plant and begin mining by open-cut methods.

This work was being done by the Montana Southern Mining Co., M. I. Leydig, manager.

Ben Harrison Fraction

The Ben Harrison Fraction, owned by Harry G. Smith of Harrison, Mont., is 5 miles up Cataract Creek from Pony at an elevation of about 7,500 feet. The ore is in a fissure vein, from a few inches to several feet in width, in granite and gneiss. The mine is claimed to have produced about $90,000 in gold and silver.

The vein is opened by two shafts 75 feet and 60 feet in depth. When the mine was visited the ore was being mined from shallow surface workings. Two to three men were working by hand methods and shipping about one truckload per month.

Lone Wolf and Cataract

The Lone Wolf and Cataract claims, adjoining the Ben Harrison Fraction, were being developed by S. C. McKitrick and partners. Some ore was being shipped from development.

The vein had been traced by trenches, short tunnels, and shafts for about 800 feet and was well-mineralized where exposed. Insufficient work had been done to determine the commercial value. The ore appeared to consist of stringers and bunches of heavy sulphide along a shear zone near the granite-gneiss contact.

Mineralization comprised chiefly pyrite, galena, and sphalerite. Shipments were said to have assayed $12 to $60 a ton in gold and silver.

Bozeman

The Bozeman mine 7½ miles from Pony and at an elevation of 8,500 feet was being operated on lease by Farrel & Manley.

The vein here was a typical quartz fissure vein on a 70° dip. In the stopes the quartz was about 4½ feet wide. Development comprised two adit drifts on the vein, each about 600 feet long. An oreshoot

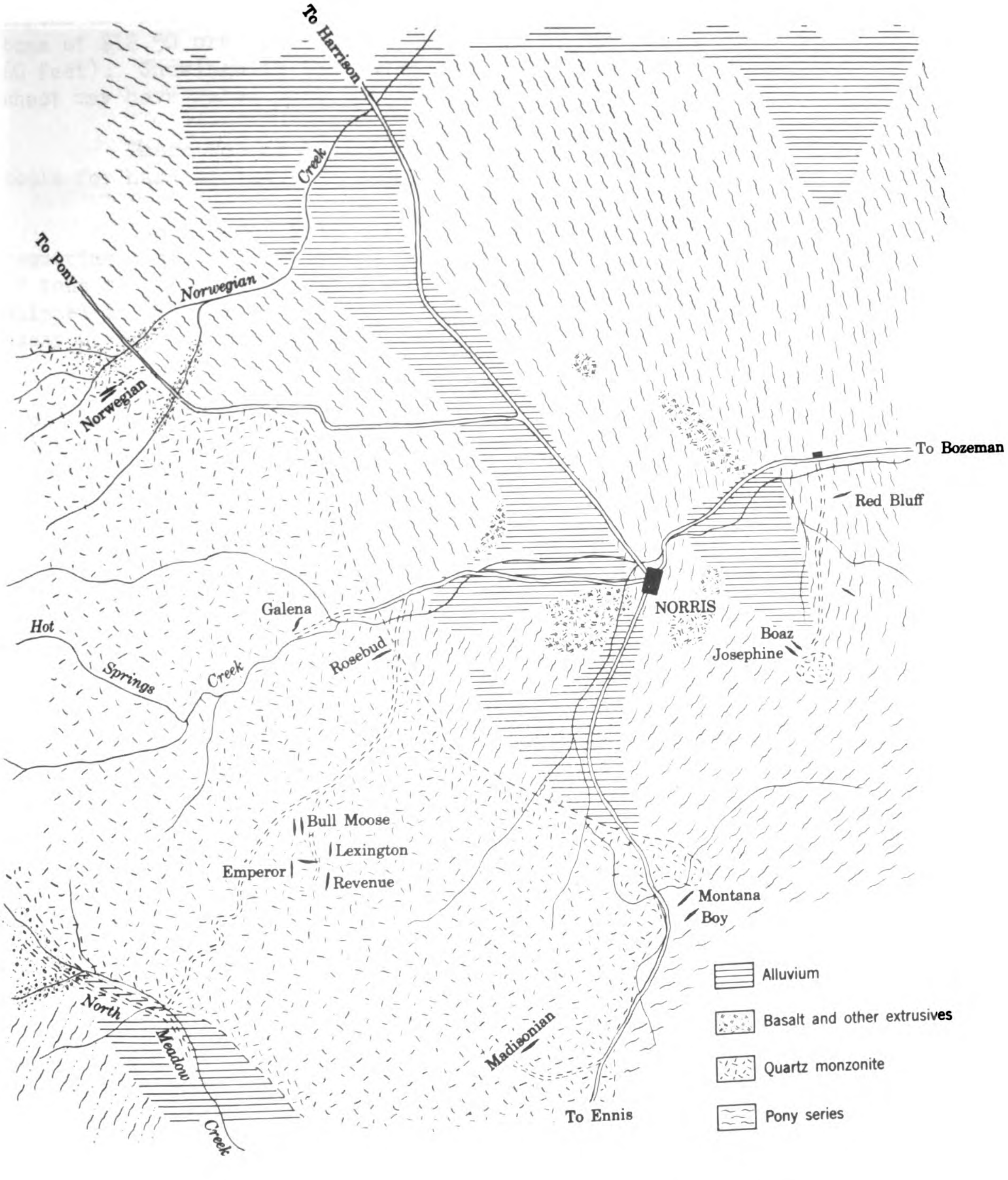

Figure 7.—Geological sketch, Norris district (after Tansley, Schafer, and Hart).

200 to 300 feet long was exposed in the upper tunnel, with the face still in ore. There were surface indications of ore for several hundred feet beyond the face. It was claimed that an engineer's report showed 7,000 tons of $12.50 ore between the upper tunnel and the surface (about 50 to 60 feet). Showings in the lower tunnel were not so good, but the ore-shoot may have raked past the face.

There was no equipment except cars, rails, an ore bunker, and tools for hand mining.

Stoping conditions were favorable. The ground stood well, requiring stull support only. One man and his small son were producing 12 tons of selected ore in 2 to 3 weeks of work. Two cars had been shipped in the spring and 12 tons in June. The shipping ore was said to assay 0.75 to 1 ounce of gold per ton.

In the preceding year about 1½ miles of road had been built from the Atlantic and Pacific claims. This was sidehill construction which required little or no rock work but considerable clearing. It was completed by four men in 6 weeks, with the aid of the county grader for 2 days.

Norris District

The mines tributary to Norris have, in the past, been grouped into several districts known as the Lower Hot Springs district, the Upper Hot Springs district, and the Norwegian district. The mines near the Madisonian mine were not, strictly speaking, included in any of these districts and might have been considered as constituting another district. All of these districts are within a short distance of the town of Norris and may, with some logic, be grouped together. (See fig. 7.)

The Washington and Potosi Hot Springs districts are also tributary to Norris but are so far away that they should be considered separately.

All mines in the Norris district are within about 6 miles of the town, nevertheless they are divided into several more or less distinct groups corresponding with the original district designations.

One group is centered around the Boaz and Josephine mines a few miles east of Norris. There have been no very large producers in this group, but the veins appear to be higher grade than the average found in the Tobacco Root region. Current production was from direct shipping ores. The Boaz was shipping about 2 cars a month and expected to increase production. The Josephine was being equipped for production on a scale comparable to the Boaz.

Much activity had begun recently on Revenue flats near the site of the old Revenue mine, which is estimated to have produced over $2,000,000 from shallow workings. Revenue flats are about 6 miles from Norris at an altitude of 5,400 feet. All properties were in the initial development stage, but all were shipping ore from development work, virtually at grass roots.

The Galena and Rosebud mines, a few miles west of Norris, would be considered part of the Upper Hot Springs district but are several miles from the group on Revenue flats.

The Madisonian, Montana Boy, Betty Mae, and numerous inactive claims form a group near the highway a few miles south of Norris.

All mines of the Norris district are within the foothills of the Tobacco Root Range, consequently there are no mountain grades. With the exception of a fairly steep but short grade to Revenue flats, the mines of the district may be reached over nearly level roads.

Vegetation is limited to grass and sagebrush. Water is scarce, but there is usually some water in the larger creeks.

Production in the summer of 1936 fluctuated greatly from day to day. It probably averaged about 800 tons a month.

Galena

The Galena mine is at the old town of Revenue 4 miles west of Norris and at about the same elevation. It was being operated by the Lakeview Gold Mines, Inc., Wm. R. Richards, superintendent.

The principal ore bodies are in sheeted zones, composed of narrow stringers of high-grade quartz in quartz monzonite. Where the stringers are closely spaced, ore bodies 6 to 10 feet wide are formed; where they fan out into "horsetails" it is occasionally possible to mine individual stringers by careful sorting. Usually, however, the stringers become too small and too widely spaced to be worked.

The main oreshoot has been mined 350 feet on the dip and 100 to 200 feet on the strike. The dip averages about 33° but ranges from nearly flat to nearly vertical. As a rule the best ore has been found on the "flats." The oreshoot splits below the 100-foot level to form a hanging- and foot-wall ore body.

The mine is developed by a 350-foot inclined shaft, and levels are opened at 100, 200, and 300 feet.

Equipment. - The mine is equipped with a 50-ton flotation mill; a single-drum, 35-hp. hoist; a 350-cubic-foot-per-minute, 75-hp. compressor; a 40-hp. centrifugal mine pump; and the necessary incidental supplies. Power was purchased from the Montana Power Co.

Mining. - When visited, the mine was operating one shift only and producing 15 tons of ore per day. About 40 gallons of water were pumped per minute.

Stopes were open, and the backs were supported by only an

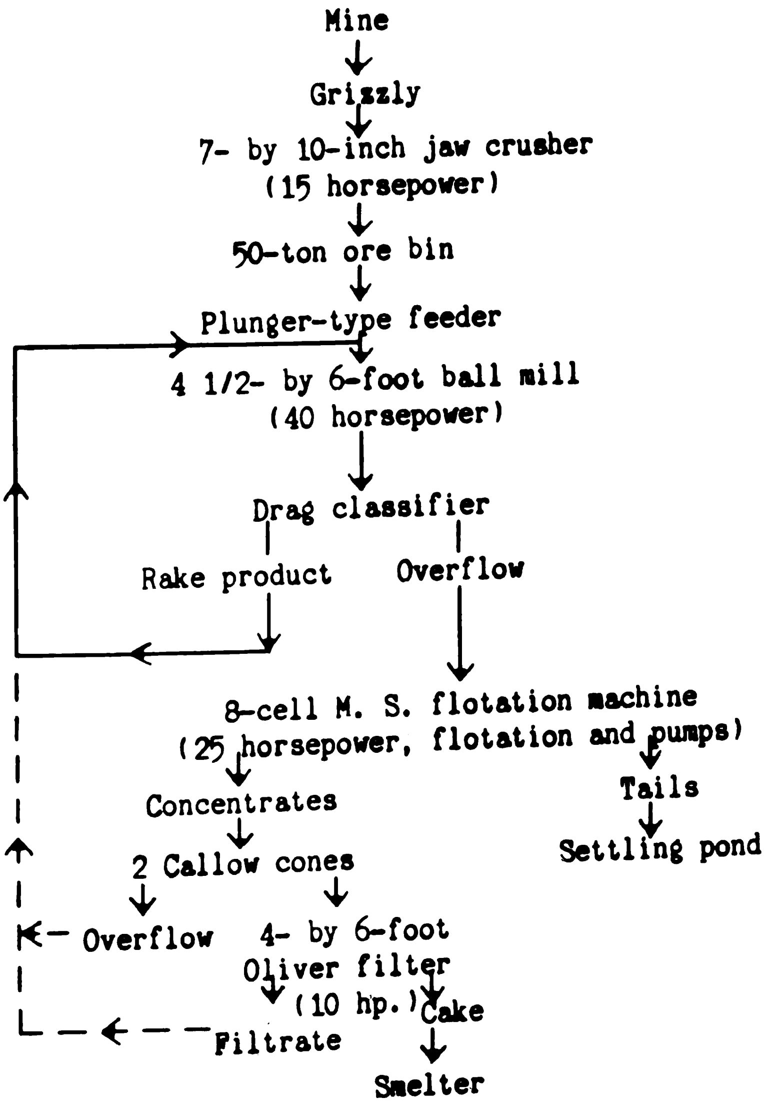

Figure 8.- Flow sheet, Galena mill.

occasional stull or gob pillar. No chutes were built in the flat stopes; the ore was scraped to the drift by hand and mucked into the cars.

One drifter machine was employed on stoping and one machine on waste development. The mine crew totaled six men.

Milling. - The mill flow sheet is shown in figure 8. Mine ore was crushed to 1 inch in a 7- by 10-inch Blake-type jaw crusher, passing thence to a 50-ton ore bin.

A plunger-type feeder regulated the feed to a 4½- by 6-foot ball mill operated in closed circuit with an Esperanza-type drag classifier.

Overflow from the classifier, at about 80-mesh, went to the first cell of an 8-cell Minerals Separation flotation machine. Concentrates were taken off the first cell, settled in two Callow cones, and filtered in a 4- by 6-foot Oliver filter. The filter operated about 3 hours per shift.

Flotation tails went direct to the settling pond.

Reagents used were sodium ethyl and amyl xanthate, Barrett No. 4, and cresylic acid.

Extraction was 90 percent on $5 to $6 heads. The ratio of concentration was approximately 40 to 1.

Smelter analysis of a typical concentrate shipment was:

Gold	ounces	5.045
Silver	do..	7.8
Lead		0
Copper	percent	3.33
Iron	do..	34.4
Sulfur	do..	38
Manganese	do..	.3
Bismuth	do..	.05
Antimony	do..	.40
Insoluble	do..	23.4

Labor. - The crew consisted of six miners and muckers, one hoistman, one ore sorter, one crusherman, one mill operator, and a superintendent.

Costs. - A rough estimate of direct costs for mining and milling, exclusive of superintendence, was:

	per day	per ton
Labor	$41.00	$2.73
Power	10.00	.67
Powder and caps	5.00	.33
Bits (detachable)	2.00	.13
Balls and reagents	1.00	.07
	59.00	3.93

Rosebud

Near the old town of Revenue, the Rosebud Mines, Inc., John Conrow, manager, was developing a quartz vein in monzonite.

A shaft 3 by 7 feet in the clear had been sunk 125 feet on the vein, at a 65° pitch. At the 95-foot level a 380-foot drift had opened up three high-grade shoots, each about 35 feet long, and considerable low-grade ore. The quartz was about 30 inches wide in the oreshoots.

Equipment comprised a Gardner Denver, 260-cubic foot, Model A - A compressor and a new Novo No. M. hoist driven by a Noble gas engine. The manager stated that gasoline consumption was about 15 gallons in 8 hours for the compressor and about 5 gallons per week for the hoist when hoisting 7 to 8 tons per shift.

Sinking costs had averaged $13.80 per foot including timber. No pumping had yet been required.

Drifting costs were $7 to $8 a foot.

A crew of four men, including the manager, was employed.

Revenue Group

On Revenue flats a group of 13 patented claims, 2 claims held by location, and 2 leased claims were being explored and developed by an association of local business men known as the Revenue Mine Developing Group. P. V. Jackson of Norris, Mont., was president and manager. The claims included the ground worked by the old Revenue mine, which is reputed to have produced over $2,000,000. Between 1901 and 1935 the recorded production of this mine was 15,842 ounces of gold and 16,878 ounces of silver from 26,095 tons of ore.

Much trenching had been done in a novel and interesting manner. A caterpillar-mounted dragline excavator had been used for 18 days at a cost of $10 per hour for equipment and operator. This had completed about 3,000 feet of trenching (estimated) at a total cost of approximately $2,000. The trenches were about 5 feet deep and 4 to 5 feet wide. Virtually no vegetation heavier than grass or sagebrush was encountered.

The trenching had exposed ore outcrops at several points along a north-south line at least 500 feet long. Old caved workings indicated probable extension 100 feet or more to the north. A 20-foot vertical shaft and two inclines had been driven at different points. Quartz lenses which dipped flatly to the east were exposed in all openings. These lenses appeared to be short but swelled rapidly to widths of 5 or 6 feet. Not enough work had been done to determine the size of these lenses or the frequency with which they occurred.

Ore was being shipped from development work. It was stated that

3 cars had been shipped in the preceding 3 weeks.

Lexington

The Lexington mine is on a claim belonging to the old Revenue group. It was being operated on lease by J. C. Frisbie & Son of McCallister, Mont. The vein strikes north, dips 45° west, and contains up to 2 feet of quartz.

Development consisted of a shaft sunk vertical for 50 feet, and then 80 feet additional on the vein. On the 50-foot level were drifts 150 feet north and 75 feet south. A drift was being driven north on the 130-foot level.

Equipment consisted of a small hoist, driven by a 6-hp. Noble gas engine, and an I. R. two-drill compressor.

About 100 tons of ore had been shipped, mostly from development work.

Bull Moose

The Bull Moose mine on Revenue flats, owned by D. C. Mather, of Anaconda, and Gordon McCloud and mother, of Norris, is a fissure vein in quartz monzonite. The vein strikes north and dips 20° to 30° west. The quartz is from 6 inches to 2½ feet wide.

The vein is developed by a 150-foot incline and a drift north on the 100-foot level. From this level a stope about 100 feet long extends to surface. The bottom of the shaft and most of the stope faces were in quartz. Presumably this quartz was too low-grade for shipping ore but might have been of milling grade.

There was no underground development work south of the shaft, but in a short adit on surface a quartz vein 3 feet wide was exposed 100 feet south of the shaft. This appeared to be a continuation of the main vein.

Past production had come from shipping ore which was said to assay from $8 to $60 in gold per ton.

Black Prince

The Black Prince claim several hundred feet west of the Bull Moose was owned by W. A. Reel and Gordon McCloud of Norris. It was opened by a 22-foot shaft from which Van L. Moore of Norris had recently shipped 6½ tons of $28 gold ore. In strike, dip, and character the vein appeared similar to the Bull Moose.

Emperor

This was a new development on Revenue flats owned by C. H.

Rutherford and R. J. Fuchs of Casper, Wyo. K. W. Leavitt and T. B. Frantz were in charge of operations.

A shaft had been sunk 90 feet and drifts driven 64 feet south and 15 feet north on a westerly dipping quartz vein. It was claimed that 7 cars of ore had been shipped from development work.

Boaz

The Boaz mine is about 5 miles by road east of the town of Norris, at a slightly higher elevation. It was being operated by the Jackpot Mining Co., C. E. Drackert, superintendent.

The vein strikes about N. 40° W. and dips 70° northeast. It is a fissure vein in gneiss; the width of the quartz ranges from a few inches to 3 feet, probably averaging about 18 inches. Two high-grade shoots were being worked; each was 20 to 50 feet long and raked eastward. These shoots had been productive to the 265-foot level and gave evidence of going deeper.

From 1870 to 1880 this mine is said to have produced about $200,000 in gold and silver, mostly from oxidized ore. Between 1902 and 1935 it produced 3,752 ounces of gold, 3,641 ounces of silver, 14,425 pounds of copper, and 30,763 pounds of lead from 1,959 tons of shipping ore. Almost all present production is from primary sulphides. The intensity of sulphide mineralization appears to be in direct proportion to the richness of the ore. Much of the sorted ore in the bunkers was almost solid sulphide. Smelter analyses showed that the shipping ore contained 12 to 14 percent iron, 1½ to 2 percent lead, and less than ½ percent zinc.

Equipment. - The mine was equipped with a 40-hp., single-drum hoist; a 220-cubic foot, 50-hp. compressor; a 40-hp., turbine mine pump; drilling machines; and accessory supplies. Preparations were being made to install additional compressor capacity for sinking.

Power was purchased from the Montana Power Co. Power costs were said to be about $250 to $300 per month.

Development. - The mine was developed by a 265-foot vertical shaft and two levels, one at 165 feet and one at 265 feet.

Mining. - All mining was directed toward the production of high-grade shipping ore only. When visited (June 1936) the following crew was employed: Two hoistmen (day and night); one blacksmith (day); one pumpman (night); one pumpman (graveyard); six miners on stoping and four miners on development; and a superintendent.

The blacksmith shop was in the hoist-compressor room so that the hoistman could act as blacksmith's helper. The small amount of steel used could be sharpened on part time. In his remaining time the black-

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smith sorted ore. Steel was sharpened by hand methods at the rate of about 30 pieces per hour. Timbering, track laying, and tramming were done by the pump men.

Stopes were mined 3 to 4 feet wide. Sorted waste was gobbed in the stope, but no effort was made to keep the stopes filled. Miners worked on stulls and mined by resuing. As much waste as necessary was first drilled and shot, planks were laid on the stulls, and the ore was carefully moiled or picked onto the planks. After the ore was sorted it was shoveled into plank slides leading to the chutes. On the surface the ore was again sorted before shipment. Miners worked in pairs; each pair had its own working place which was not touched by the opposite shift.

With this method six miners produced about 120 tons of sorted ore per month, or three-fourths ton per man-shift on direct stoping. Production for all men employed averaged one-fourth ton per man-shift.

The shipping ore averaged 2 to 4 ounces of gold per ton.

Josephine

The Josephine mine is within a few hundred feet of the Boaz. The veins are similar to the Boaz, approximately parallel, and dip about 50° northeast.

The Josephine Mining Co. was building a new headframe and installing new hoisting equipment preparatory to shipping. An inclined shaft had been sunk 250 feet on the vein and levels cut at 100 and 150 feet. On the 100-foot level drifts had been driven 100 feet southeast and 75 feet northwest; on the 150-foot level a drift had been driven 275 feet southeast and a crosscut 106 feet south.

Six miners and three topmen were employed.

Betty Mae

The Betty Mae mine is 4.3 miles south of Norris and a few hundred yards east of Montana Highway 1. It was owned by O. F. Curteman of Norris and operated under lease by John Bacca and William Maichel.

The ore consisted of quartz lenses and stringers in a crushed zone 3 to 4 feet wide in gneiss. The vein strikes N. 45° E. and dips 45° to 60° northwest.

Development comprised an 85-foot inclined shaft, a drift 55 feet north and a crosscut to the surface at the 30-foot level, and drifts 55 feet north and 10 feet south on the 85-foot level. On the surface an open-cut exposes 3 feet of quartz 175 feet southwest of the shaft.

The mine was equipped with a small compressor and hoist driven by a Dodge automobile engine.

Two men and a boy had developed the mine in 7 months, shipping 6 tons of sorted ore. Nearly all the work had been in ore; the sorted low-grade ore was piled in a dump.

Montana Boy

About 1,000 feet northwest of the Betty Mae mine is the Montana Boy, owned by the Montana Idaho Development Co. Jack Lemon of Norris was the local agent.

There are two veins 40 feet apart where exposed by surface workings. No. 1 vein strikes N. 25° E.; no. 2 vein strikes N. 40° E. Both dip about 35° northwest. The ore consists of quartz lenses and stringers in a crushed zone, 4 to 5 feet wide, in gneiss.

On no. 2 vein was an 80-foot inclined shaft and drifts 134 feet northeast and 46 feet southwest at the 60-foot level. It was said that 24 tons of shipping ore, yielding $7,000, had been taken from this shaft in the last 1½ years. In earlier days some shallow stoping had been done on no. 1 vein.

Some old and new surface workings 400 feet southwest of the shaft exposed about 5 feet of quartz.

A crosscut from Bradley Creek cuts both veins at 240 feet, slope distance, below the outcrop. Some drifting had been done on both veins. Ore appeared to be entering no. 2 vein 140 feet southwest of the crosscut.

This mine had a reputed production of $30,000 in the eighties and nineties. Numerous old workings nearby were worked in the early days. Winchell 12/ attributes a production of $200,000 to the Grubstake and Montana Boy; this probably includes all of these old workings.

Madisonian

The Madisonian mine, known originally as the Hendricks, was one of the early large producers of the Hot Springs district. It was closed in 1893. No dependable records of production are available. When the mine was visited W. C. Templin of Norris had a short-time lease from the owners, the L. Z. Leiter Estate of Chicago.

The mine is 6 miles south of Norris and 1 mile west of Montana Highway No. 1. The old workings were inaccessible, but according to local information the mine was developed by a 500-foot inclined shaft and

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12/ Winchell, A. N., Mining Districts of the Dillon Quadrangle, Mont., and Adjacent Areas: U. S. Geol. Survey Bull. 574, 1914, 191 pp.

perhaps 1,000 feet of development work on each of four levels at 100-foot intervals. It is claimed that ore 3 feet wide, averaging about \$9.00 a ton at \$20.67 per ounce for gold, was left between two of the lower levels.

Water is now standing at about the 200-foot level. It is said that when the mine was operating 500 gallons per minute was being pumped, and that this was a major factor in causing the shut-down.

In the last year leasers had shipped about 50 tons of ore from surface workings on newly opened parallel veins or extensions of the old vein. This ore averaged about \$27 per ton on net smelter returns.

The veins, where exposed, had a general strike of N. 45° E. and dipped 35° to 45° northwest. Quartz occurred in lenses up to 5 feet wide along a sheared and crushed zone in monzonite.

Norwegian

The only active lode mine in the Norwegian district was the Norwegian mine, which was being reopened by J. T. Dravenstott of Norris. This mine was said to have produced \$50,000 from high-grade shipping ore in the early days of the district. It is in the foothills several miles west of the Montana Highway 1 about 7 miles northwest of Norris.

There are two nearly vertical veins in a marginal phase of the monzonite batholith. The veins strike N. 20° E. and N. 40° E., respectively. They are about 250 feet apart where developed.

Development comprises a 110-foot vertical shaft on no. 1 vein. From the bottom of the shaft is a drift northeast on the vein and a crosscut to no. 2 vein. On no. 1 vein two shoots, one about 40 feet long and another probably somewhat longer, had been stoped to surface. These shoots were said to have produced high-grade gold ore.

No. 2 vein was said to be wider and lower grade but was inaccessible. There were surface evidences of considerable stoping.

The water level appeared to be just below the bottom of no. 1 shaft.

Washington District

The mines in the Washington district lie on the slopes of South Baldy Mountain and Wards Peak. Most of the claims are at elevations of 8,000 to 9,000 feet. The Missouri-McKee, Lehigh, Hatfield, and other mines south of South Baldy Mountain are reached via the valley of South Meadow Creek. The Frisbee, New Deal, and other properties on the north slope of Wards Peak are reached via the valley of North Meadow Creek. Either group is about 18 miles from Norris; the last 7 or 8 miles is rough mountain road but may be traversed by automobile in good weather. The roads could be greatly improved at comparatively small expense.

There is abundant timber and water in the district. Small-scale hydroelectric power has been developed at the Missouri-McKee.

Production was small in 1936, but indications were that the Heater mine would be developed to the producing stage some time in 1937.

New Deal or Heater

The only activity in the district was at a comparatively new development known as the New Deal, owned by C. A. Heater of Norris. A vein of quartz 3 to 6 feet wide had been opened at three points along a strike distance of 500 to 600 feet. A 60-foot drift on the vein was in 5 or 6 feet of ore throughout its length; 200 feet southeast of this adit a 20-foot shaft was in 4 to 5 feet of ore; about 300 or 400 feet southeast of the shaft was an open-cut exposing 3 feet of ore. About 7 tons of high-grade ore had been shipped from development work.

The vein strikes S. 60° to 70° E. and dips 35° to 40° southwest. The wall rock is gneiss near the contact of a granitic intrusion, probably quartz monzonite.

Missouri-McKee

Although not active in the summer of 1936, this group has been the largest producer in the Washington district. Its officially reported production since 1905 has been 16,664 ounces of gold and 41,958 ounces of silver, with some copper and lead, from 14,340 tons of ore. Production figures prior to that time are not reliable.

The mine was equipped with a fairly new 35-ton cyanide plant, compressor, etc., driven by a small hydroelectric power plant.

The ore bodies are flat-lying quartz veins on the contact between gneiss and a sill-like andesite intrusive. According to Winchell[13] the veins are 1 to 4 feet thick and very uniform. Hart[14] was of the opinion that oreshoots were localized along small synclinal folds or troughs on the contact. Local information indicates that exploration has not been pushed far beyond the limits of the original oreshoots.

Hatfield

The Hatfield mine was said to have shipped ore recently from an

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[13] Winchell, A. N., work cited in footnote 12.

[14] Hart, Lyman H., A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Mont.: Memoir 9, Montana Bureau of Mines and Geology, Part 2, 1933, p. 55.

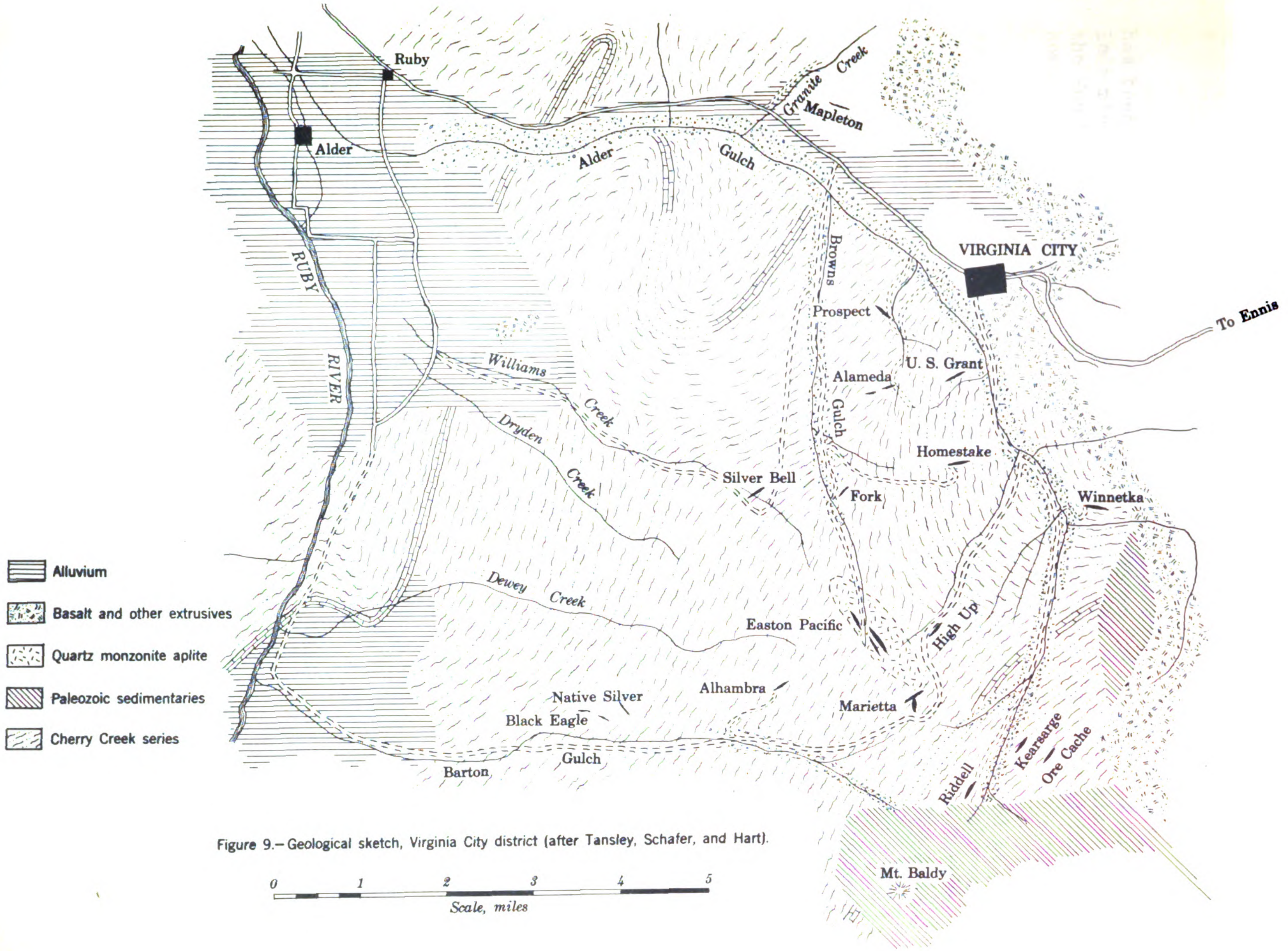

Figure 9.– Geological sketch, Virginia City district (after Tansley, Schafer, and Hart).

oreshoot about 600 feet down the dip of the andesite-gneiss contact from the Missouri mine.

Virginia City District

The placer-gold production of the Virginia City district (fig. 9) has been several times greater than the combined production from all the lode mines of the Tobacco Root region. Until the recent installation of the Humphrey dredge on Alder Gulch placer mining in the district had, however, been quiescent for many years.

The lode mines of the district have produced ore valued at 3 or 4 million dollars. Several important producers have been developed, notably the Kearsarge and Oro Cache in the early days, later the Easton-Pacific, and at present the Marietta. Of these the Easton-Pacific has been the largest producer.

Although the region was originally divided into several districts there is little reason for such a division, except for the group of silver veins on Barton Gulch several miles west of the Marietta. Nearly all other veins of the district are scattered along a belt several miles wide between Mount Baldy and Virginia City. There are few differences in the general character of the ores.

With the exception of the mines near the head of Browns Gulch and Barton Gulch, most mines of the district are easily accessible. Most of the exceptions noted may be approached on a moderate water grade.

Vegetation is scarce near Virginia City and for several miles south. Mountain slopes near the headwaters of the larger streams are heavily timbered.

Water is available in the largest streams. Smaller streams are intermittent.

When visited, the district was producing between 2,500 and 3,000 tons of ore per month. Probably 100 to 200 tons was direct shipping ore; the remainder was being treated in the Marietta, Prospect, and Winnetka mills.

Prospect

The Prospect mine about 1 mile west of Virginia City was being operated by the Virginia City Gold Mining Co.

The ore occurs in strong, somewhat lenticular bodies of quartz along a fissure in gneiss. The vein strikes northwest and dips 60° to 70° northeast. The quartz has a maximum width of about 7 feet; the average width is probably about 3 feet. Considerable gouge and shear material on the wall breaks with the ore; consequently stoping widths average about 5 feet.

Oreshoots occur along a strike length of about 900 feet; the principal shoot is about 400 feet long and has been worked to a depth of approximately 400 feet below the highest outcrop. (See fig. 2.)

Most of the ore mined to date has been oxidized, although unaltered sulphides occur on the lower levels. The principal sulphide minerals are galena, chalcopyrite, and pyrite.

Development. - The mine was developed by three adit levels, a 150-foot winze, and short drifts from the winze at the 100- and 150-foot levels. The main adit level has explored the vein fracture for 1,200 feet or more along the strike.

Equipment. - The mine was completely equipped with compressor, mining equipment, blacksmith shop, assay office, and 60-ton flotation mill. Because of the proximity of Virginia City boarding-house facilities were unnecessary.

Mining. - Stoping was by open overhand or shrinkage methods. The ground was supported by occasional stulls with headboards. When convenient, ore was retained in the stopes as in shrinkage stoping. Otherwise the stopes were open, and the miners worked on stulls.

Stoping costs, exclusive of development or preparation, are indicated by the mine foreman's record of stoping operations in one small stope for 1 month. The stope was about 4 feet wide; a raise on one end was maintained as a manway.

			Per ton	Stoping Cost per ton
Man shifts		155	0.33	$1.402
Stoper-machine shifts		41	.09	
Detonators		326	.70	.009
Fuse	feet	1,872	4.02	.028
Powder	sticks	1,594	3.41	.307
Stulls	linear feet	300	.64	.026
Pole lagging	do.	1,823	3.91	.039
Plank	do.	976	2.10	.088
				$1.899
Ore broken	tons	466		
Per man shift	do.	3		
Per machine shift	do.	11.4		

Milling. - The mill flow sheet is shown in figure 10.

Mine ore was trammed to the mill by hand (about 900 feet) and dumped on a 6-inch grizzly where the oversize was broken with hammers. The ore was crushed in a No. 2½ crusher set for 1¼-inch discharge.

A trommel with ¾-inch round holes and a set of 30- by 12-inch

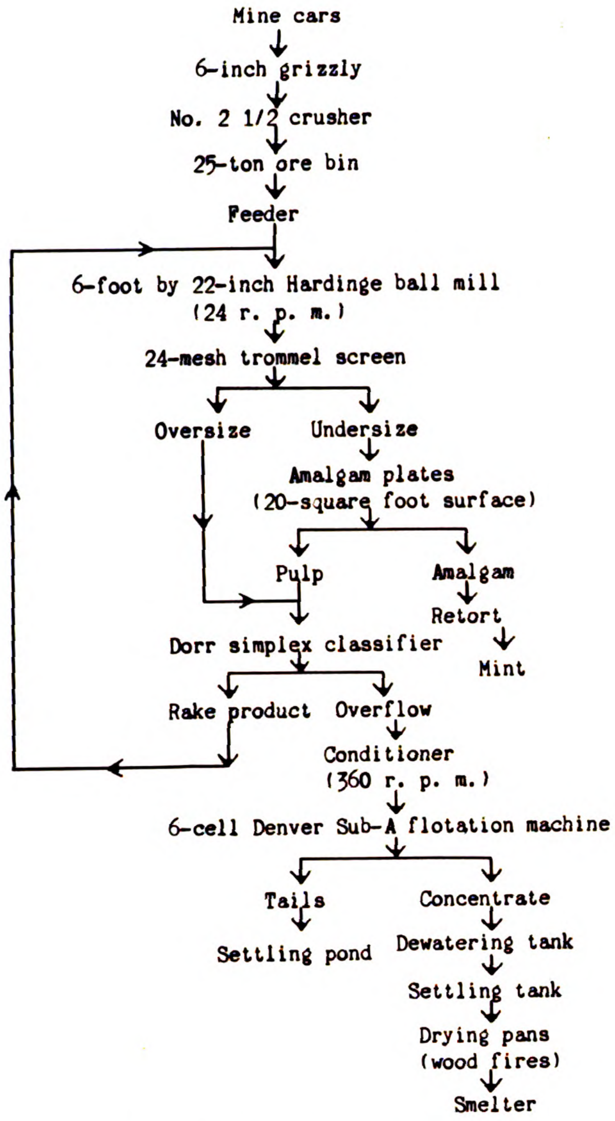

Figure 10.- Flow sheet, Prospect mill.

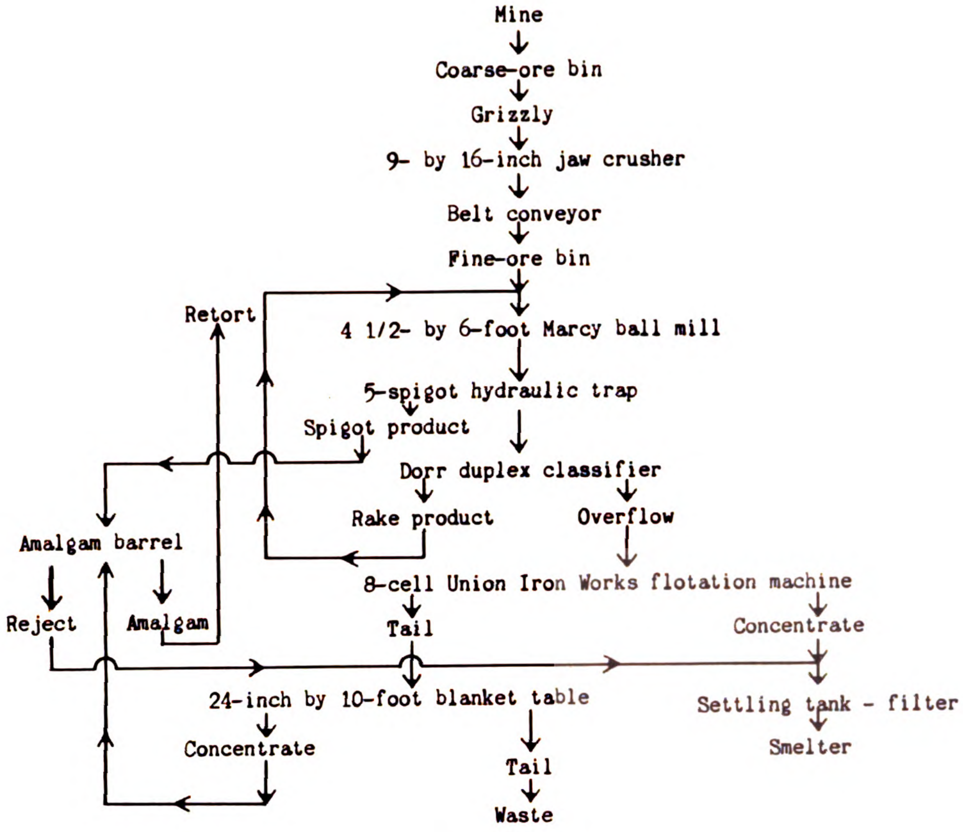

Figure 11.- Flow sheet, Marietta mill.

rolls were on the floor but not in use.

Crusher product went to a 25-ton ore bin, thence to a 6-foot by 22-inch Hardinge-type ball mill, on the discharge end of which was a 24-mesh trommel screen.

Screen oversize went direct to a Dorr Simplex classifier; undersize passed over an amalgam plate set at a slope of 2½ inches to the foot, thence to the classifier. Classifier rake product was returned to the ball-mill feed; overflow, at about 65 percent minus 100-mesh, went to a conditioner and thence to the first cell of a 6-cell Denver Sub-A flotation machine.

Flotation concentrates were taken off the first cell; froth from the remaining five cells returned to the first cell. Flotation tails went direct to a settling pond. Flotation concentrates were dewatered and settled in tanks, then dried on pans over a wood fire.

Flotation reagents used were:

	Pound per ton
Aerofloat	0.15
Barrett No. 4	.064
Sodium xanthate	.10
Soda ash	.092

Ball consumption was 2.68 pounds per ton.

Mill heads were said to average 0.24 ounce of gold per ton; tails 0.04 ounce of gold per ton. About 30 percent of the total values were recovered on the plates and 50 to 55 percent by flotation.

Concentrates assayed 9 to 15 ounces of gold, 100 to 120 ounces of silver, 7 to 8 percent of lead, and 1 to 2 percent of copper per ton. Forty tons of ore was milled in 16 hours.

Power. - The connected power was as follows:

	Horsepower	Horsepower
Mill:		
Coarse crusher Trommel	30	
Ball mill	75	
Classifier Pump	20	
Flotation	12	137
Mine:		
Compressor	75	
Hoist	50	125
Total		262

Average power load actually required by both mine and mill was about 150 horsepower, of which two-thirds was used by the mill; power cost was approximately $540 per month when operating 16 hours per day.

Power was purchased from the Montana Power Co.

Alameda

The Alameda mine is about 2 miles by good dirt road southwest of Virginia City. It was being operated under option by D. A. Harris. Operations had been confined to shipping ore from the margins of old stopes in the upper workings.

Ore bodies are tabular quartz veins in a fissure in gneiss. The average strike is about N. 70° E. and the dip 50° north. The quartz was from 6 inches to 5 feet wide, probably averaging12 to 18 inches. The average assay of 41 small shipments by leasers between 1906 and 1915 was 1.64 ounces of gold and 33.9 ounces of silver per ton.

Development comprised a 768-foot adit drift, over which were 100 to 150 feet of backs; a 300-foot vertical shaft; and drifts at the 40-, 90-, 150-, 220-, and 270-foot levels. (See fig. 2.) This work was said to have been done between 1885 and 1888. It is now (1936) full of water below the 40-foot level. The shaft appeared to be in good condition.

According to the old maps an oreshoot 300 feet long on the surface had tapered to about 200 feet at the 150-foot level; a small stope was shown on the 220-foot level, but no stoping was indicated on the 270-foot level. On the surface and in the adit drift ore was more or less continuous but was considerably broken up by premineral faulting for 400 feet southwest of the main oreshoot; this ore had been stoped to the surface. Adjoining the Alameda on the southwest, an oreshoot on the Bamboo Chief claim was indicated as being several hundred feet long. The map shows a 120-foot shaft and several hundred feet of drifting and stoping on this shoot.

No deep-level exploration was indicated southwest of the main oreshoot on the Alameda. Below the adit on the Alameda is a small mill building containing a battery of ten 1,000-pound stamps. Stamps and building seem to be in good condition. Compressed air for mining is supplied by an 8- by 10-inch compressor driven by a 25-horsepower motor. Power is purchased from the Montana Power Co.

U. S. Grant

The U. S. Grant mine has been one of the most consistent producers in the district although at no time a very large one. From 1908 to 1926, inclusive, the officially reported production was 834 ounces of gold and 46,393 ounces of silver from 1,764 tons of shipping ore.

Some production was reported for nearly every year between 1908 and 1926; none has been reported since 1926, although some ore has undoubtedly been mined.

The lowest adit is near the Alder Gulch road about 1 mile south of Virginia City. The mine was being operated by D. A. Harris, who was shipping ore from the old dumps. It was stated that net smelter returns of $1.50 to $4.50 a ton had been obtained from 600 tons of dump ore.

Quartz lenses 3 to 8 feet wide occur along a strong crushed and sheared zone in gneiss. The strike is about N. 45° E.; the dip is 45° northwest. As a rule the high-grade ore is found in narrow streaks along the hanging or footwall. High-grade ore is also found in narrow stringers through the crushed vein matter.

The mine is developed by six adit drifts; the uppermost adit is about 500 feet vertically above the lowest. The vein outcrops are inclined in a sweeping curve up the hillside. Consequently, each adit is offset southwest from the next lower adit, with the result that the area prospected by the drifts has a northeasterly rake. Most of the stoping has been done for a distance of about 600 feet along adits nos. 2 and 3. The largest stope was about 200 feet long.

Winnetka

The only mill operating on Alder Gulch was at the Winnetka mine 4.6 miles from Virginia City at an altitude of 6,800 feet.

Officially reported production from 1909 to 1932 was 3,205 ounces of gold and 4,747 ounces of silver from 3,322 tons of ore. Most of this was from shipping ore. During 1931 and 1932, 881 tons of milling ore yielded 236 ounces of gold.

Geo. H. Gohn has operated the mine since 1931. Starting without capital, he had equipped the mine and built a small amalgamating-concentrating mill. Gohn estimates that the mine has had an all-time production of about 6,000 ounces of gold.

The ore consists of strong lenses of quartz in a wide crushed and sheared zone in gneiss. The strike is S. 76° E.; the dip is 50° south. Where accessible, the quartz lenses were not long but swelled rapidly to widths of 4 or 5 feet. In the areas already stoped the lenses were closely spaced.

Development comprised a 600-foot adit drift, said to be entirely in ore. Over half of this was inaccessible because of caving, but surface workings indicated that ore existed at least in places throughout this distance. Near the adit, about 240 feet of continuous stoping extended to the surface, a maximum distance of about 200 feet on the dip of the vein.

Equipment. - The mine was equipped with a 25-ton amalgamating-concentrating mill, an Ingersoll-Rand, type 20, 210-cubic foot compressor driven by a 30-hp. motor, shops, bunkhouse, and boarding house.

Mining. - The mining method in use was a combination of square-set and cut-and-fill. Sills were closely timbered. The first cut above the sill took out a wedge-shaped area between the sill cap and the hanging wall of the crushed zone. The next cut was on the dip of the vein and was timbered with sets standing normal to the dip. Chutes were then built, the last set of timbers was lagged over, and stoping was continued upward by cut-and-fill methods. The ground was heavy, and it was always necessary to support it with stulls or half sets until filled. In places full sets were required. Filling was obtained from the gouge and crushed material within the vein fissure.

Milling. - Mine ore was dumped into a 20-ton bin, from which it passed over a grizzly to a 7- by 10-inch Blake-type jaw crusher.

The crusher product was lifted by a bucket elevator to an 80-ton ore bin, from which it went to a 10-foot Lane Chilean mill revolving at 8 r. p. m. The mill was equipped with 30-mesh screens.

The mill product passed over an amalgam plate, thence to a Wilfley table which produced a final tail and a finished concentrate.

Mill data. - Recovery was distributed as follows:

	Percent
Lane mill (inside amalgamation)....	65
Plates............................	4 to 5
Tables............................	4 to 5
Total recovery................	73 to 75

Heads averaged 0.3 to 0.4 ounce of gold per ton.

Mill capacity - 1 ton per hour on hard quartz; $1\frac{1}{2}$ tons per hour on oxidized ore. Actual operating capacity, including shut-downs, 15 to 20 tons per day.

Shoes and dies - manganese-steel shoes and Latrobe or Midvale dies used. One set lasted 7,000 to 10,000 tons of ore; cost $700.

Screens - set lasted 500 tons.

Power. - Connected horsepower for mine and mill was as follows:

	Hp.
Compressor....................................	30
Mill and crusher..............................	50
Table...	5

Power consumption at capacity production was about 24,000 kw.-

hr. per month. Peak-demand load rating was 50 hp.

Labor. - Labor required for capacity operation was:

Miners and muckers	8
Millmen	3
Blacksmith	1
General laborer	1
Superintendent	1

Riddell

E. L. Riddell of Alder, Mont., was developing a strong quartz vein on Alder Gulch, 8 miles from Virginia City. Where the vein was exposed by a crosscut it was 13 feet wide. A drift 100 feet southwest of the crosscut had been driven alongside the vein and did not expose its full width. Another vein, 6 feet wide, had been intersected by the crosscut 100 feet southeast of the large vein. Both veins had a southwest strike and a nearly vertical dip.

Dump ore was being shipped to the Prospect mill at Virginia City. Plans were being made to ship 50 tons a day of newly mined ore from the large vein. Ten men were employed. They were working by hand methods, but a compressor was to be installed.

Silver Bell

The Silver Bell is 5.5 miles by road southwest of Virginia City or 6 miles by road southeast of Alder. It was being reopened, under option, by Rupert Garrison of Virginia City.

The old workings, said to have been abandoned before 1900, indicated a comparatively shallow shaft and about 250 feet of stoping along the strike. Other old surface work indicated that some ore had been mined along a total strike distance of about 600 feet.

The present operators were sinking a 4- by 6-foot vertical shaft, from which it was planned to crosscut to the vein at the 150-foot level.

Equipment comprised an old Ingersoll-Sergeant compressor driven by a Hudson auto engine at 280 r. p. m.; a Weber-Case, 15-hp. gasoline-driven hoist; and the necessary accessory supplies. The compressor delivered 145 cubic feet of air per minute and used 10 gallons of gasoline in two shifts. The hoist used 5 gallons of gasoline in two shifts.

An 18-foot timber head frame had been erected by three men in 3 days. An additional 4 days were required to put the head frame and shaft collar in shape for sinking.

Sinking had commenced on July 13; the shaft was down 100 feet when visited on August 12. The ground was soft, having required only four boxes of powder for the 100 feet. From 15 minutes to 1 hour each shift was consumed in bailing water.

Sawed timber cost $25 per thousand feet delivered. About 100 board feet were required per foot of shaft.

The following crew was employed: Four miners in bottom (two each shift); two hoistmen (one each shift); one topman; one blacksmith-handy man; one timber framer; one foreman.

Homestake and Blackrock

The Homestake and Blackrock is on the ridge between Browns Gulch and Alder Gulch 7.5 miles by road from Virginia City. The altitude is probably about 7,000 feet. The mine was being operated under option by Frank Hammond of Virginia City. With two helpers, Hammond had mined about 100 tons of shipping ore in 3 months by hand methods. This ore was stated to assay from $15 to over $50 a ton in gold and silver.

The ore occurred in flat-lying, tabular quartz veins in gneiss. The quartz was 2 to 5 feet wide; the strike was about N. 60° E. and the dip 20° to 30° northwest.

Development consists of a 900-foot adit crosscut and drift. Old stopes extended continuously for about 300 feet along the drift to a cave, beyond which the drift was said to be in ore for several hundred feet more. Underhand stopes had been worked down the dip about 100 feet below the drift. Many stope faces were in quartz; most of the current production was being mined from around the edges of the old stopes. Stopes were open and were supported by stull and headboard only.

It was said that a crosscut from the Alder Gulch side would tap the vein about 400 feet (on the vein) below the present workings.

Easton-Pacific

The Easton-Pacific mine has been the largest producer in the Virginia City district. Production prior to 1902 is not recorded. Some production was reported for nearly every year from 1902 to 1922, inclusive. The officially reported production from 1902 to 1935 was 22,091 ounces of gold and 759,148 ounces of silver from 70,049 tons of ore. Most of this ore was milled. The records for 11 years of milling indicate that the ratio of concentration was about 24 to 1.

The mine is near the head of Browns Gulch, 7.3 miles by road from Virginia City, at an altitude of about 7,000 feet. It was being reopened by L. V. Hansen of Virginia City and E. P. Scallon of Crosby, Minn. Preparations were under way to mine a considerable tonnage of ore said to be left in the upper stopes, after which it was planned to unwater the mine and explore the deeper levels.

There are several parallel veins in a lens-shaped stock, classified by Winchell[15] as a quartz-monzonite aplite. The Easton vein has been the principal producer. It strikes northwest and dips steeply northeast. According to Winchell[16] the orebodies were 18 inches to 6 feet wide and were mineralized with free gold, auriferous pyrite, tetrahedrite, sphalerite, stibnite, and argentite.

Two major oreshoots have been developed by adits, a 400-foot vertical shaft, and a winze. The bottom of the winze is said to be in ore at a depth of 700 to 800 feet below the highest outcrop.

North Louain

The North Louain adjoins the Easton-Pacific on the northwest and appears to be in a continuation of the Easton-Pacific vein system. The only development appeared to be an adit drift and a stope 50 feet long which had been worked to surface - 25 to 50 feet above the drift. The drift was caved beyond the stope. However, surface outcroppings of quartz were visible some distance to the northwest.

Lewis Gilbert and James Wright were mining under lease a small block of ore adjoining the old stope. The vein was 5 feet wide, including 18 inches of shipping-grade ore. About 40 tons, said to assay $15 to $28 a ton, was on the dump ready to ship.

Alhambra

The Alhambra is on the mountainside above Barton Gulch about 16 miles from Alder. It was temporarily inactive but was said to have shipped one car of $12 to $35 ore during the summer. A 200-foot adit crosscut had recently been completed; it was said to have cut a 4-foot vein.

There are some old workings, now caved. The property is owned and operated by J. L. Jay of Alder.

Fork

The Fork mine, owned and operated by Pete Rostad, is near the Browns Gulch Road 6 miles south of Virginia City.

A 2-foot quartz vein, in a crushed and sheared zone in gneiss, strikes N. 35° E. and dips 20° southeast. It is developed by an adit drift along which the vein has been stoped for about 100 feet. Shipping ore was being mined by hand methods.

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[15] Winchell, A. N., work cited in footnote 12.
[16] Winchell, A. N., work cited in footnote 12.

Marietta

The Marietta mine is at the head of Barton Gulch at an elevation of about 7,500 feet. It is reached by a good mountain road 17 miles up Barton Gulch from the town of Alder.

Before the present operators took hold, the Marietta had been operated spasmodically for a number of years, during the course of which considerable development work had been completed. Apparently, none of the earlier operations met with success. However, the Marietta Mining Co., under the management of W. L. Bell, commenced operations in 1935 and, by the summer of 1936, was on a dividend-paying basis. Production has been maintained at approximately 1,000 tons per month (since increased to 1,300 tons).

Surface plant. - The surface plant consists of a 50-ton flotation mill, sawmill, blacksmith shop, assay office, cookhouse, bunkhouses, and family cabins.

An Ingersoll-Rand, two-stage (12- by 15-inch, 12- by 9-inch) compressor supplies compressed air for the mine.

All power is purchased from the Montana Power Co.

Mining. - When the mine was visited production was being obtained from two oreshoots, each on a different vein. The orebodies occurred in quartz lenses or tabular veins occupying fracture zones associated with aplite dikes in pre-Cambrian gneiss. Mineralization consists principally of free-gold auriferous pyrite, with some arsenopyrite and galena.

The "Metallic" vein strikes about N. 45° E. and dips 35° to 45° southeast. The width of the vein averages about 5 feet.

The Marietta vein is somewhat narrower, averaging 2 to 2½ feet. This vein strikes almost due north and dips steeply to the east.

Each oreshoot has a productive strike length of 300 to 350 feet, but neither has been explored at depth. At the time of visit a winze was being sunk on the Metallic vein.

The mine is developed by a 900-foot adit crosscut to the veins and considerable drifting on each vein. There is 200 to 300 feet of stoping above the adit level.

An overhand, open-stope mining method was being used; the back was supported by stulls and half sets. In the flat stopes on the Metallic vein it was necessary to lay plank slides from the drift to the working face. The ore was scraped down these slides by hand.

At this time considerably over half the ore was being obtained from development work; stoping operations were of secondary importance. This is well illustrated by the division of mine labor, which was as follows:

Miners - stoping	2
Miners - sinking (this includes hoist man)	6
Miner - drifting	1
Muckers and trammers	7
	16

The manager stated that about 18 tons of ore per day was being obtained from the winze, 6 tons of ore per day from drifting, and the remainder (about 16 tons) from stoping.

Milling. - The mill flow sheet is shown in figure 11. Mine ore is crushed to $\frac{3}{4}$-inch size in a 9- by 16-inch jaw crusher, from which it is carried by belt conveyor to the fine-ore bin.

From the fine-ore bin the ore goes to a $4\frac{1}{2}$- by 6-foot Marcy ball mill turning at 25 r. p. m. Ball consumption was about 6 pounds of cast-iron balls per ton of ore crushed.

The ball mill operates in closed circuit with a Dorr Duplex classifier. Between the ball mill and the classifier is interposed a 5-spigot hydraulic trap to catch the coarse gold. The spigot product is drawn off at about $\frac{1}{2}$-hour intervals and totals about 150 pounds of concentrate per day.

The hydraulic trap consists of five pockets, each 4 inches wide. The successive pockets range in length and depth from about 5 inches long by 20 inches deep at the feed end of the trap to about 12 inches long by 12 inches deep at the discharge end. Each pocket tapers gently toward the bottom.

The classifier overflow (at about 50 percent minus 200-mesh) goes to the first of eight Union Iron Works flotation cells. Concentrates are taken off the first cell only; a ratio of concentration of about 40 to 1 is obtained. The remaining seven cells are used as roughers, the froth from each returning to the first, or cleaner, cell.

The following reagents were used:

	Pound per ton
Soda ash	0.5
Amyl xanthate	.1
Cresylic acid	.1
Aerofloat 25	Some

Tails from the last cell pass over a 10-foot by 24-inch blanket table, thence to waste. Blankets are changed once a day, but heads to the blanket table are so low that very little recovery is obtained here.

Total recovery was 0.27 ounce of gold and 1.11 ounces of silver per ton. A 90- to 93-percent extraction was made. Of this, about 30 to 50 percent was recovered in the hydraulic trap and virtually all the remainder in the flotation concentrate.

Concentrates from the trap and blankets are treated in an amalgam barrel, and the resulting amalgam is reduced to bullion.

Flotation concentrates go to a combination settling tank and filter of local construction. This comprises a 10- by 4- by 4-foot wooden tank, in the bottom of which is a framework about 1½ feet high by about 9 feet long by about 4 inches wide. This framework is covered with filter cloth and the interior connected to a vacuum pump. When the tank has been filled with flotation froth, a 12- or 13-inch vacuum is formed in the filter and continued for 24 hours. The solution is thus drawn off through the filter and leaves a cake containing about 12 percent moisture. One batch run produces about 1,200 pounds of concentrate. To maintain continuous operation it is, of course, necessary to use two tanks alternately. To facilitate handling of the dry concentrates one end of each tank is removable.

Costs. - Costs for the 6 months January to June 1936 were as follows:

	Per ton		
Mine labor:			
Stoping	$0.648		
Development	.947		
Tramming	.439		
Total	2.034	2.034	
Mine power and supplies:			
Power	0.132		
Supplies	.574		
Capital equipment	.227		
	.933	.933	
Total mining		2.967	2.967
Milling			1.630
General expense:			
Timber	0.209		
Assaying	.193		
Hauling	.284		
Miscellaneous (office, etc.)	.245		
Total	.931		.931
Total mining and milling			5.528
Tonnage mined and milled	6,163		
Man shifts worked	4,765		
Average wage per shift	$4.388		

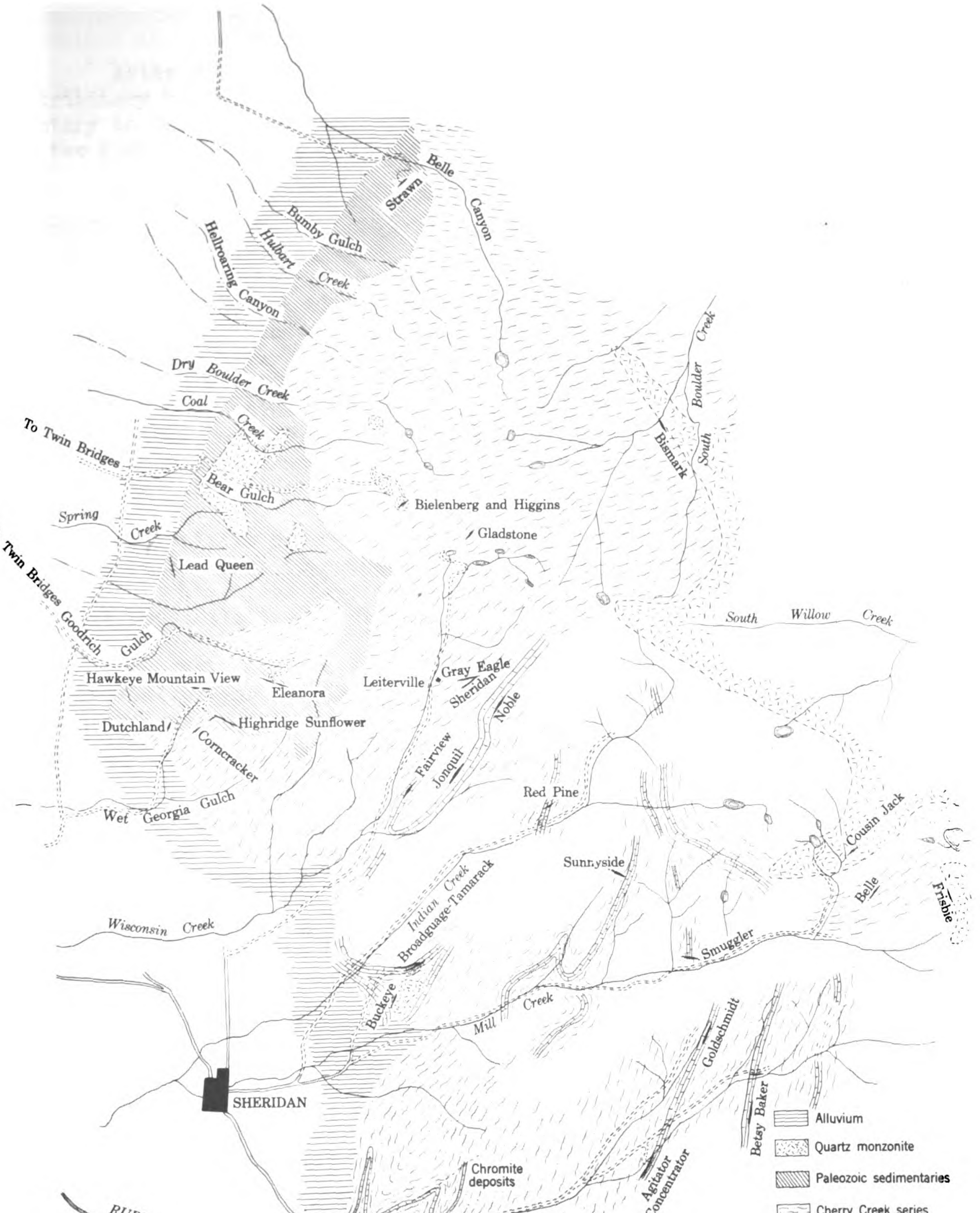

Figure 12.—Geological sketch of Sheridan and Tidal Wave districts (after Tansley, Schafer, and Hart).

Sheridan and Twin Bridges Districts

Aside from the fact that the mines from Wisconsin Creek south are tributary to Sheridan while those north of Wisconsin Creek are tributary to Twin Bridges, there is little reason for dividing the area into two districts. (See fig. 12.)

The mines are widely scattered around the western end of the Tobacco Root batholith. Although there are marked differences in the character and mineralization of individual veins the general characteristics of the two districts are similar. Mineralization varies with little regard for geographic position, but probably is governed to some extent by zonal relations, from pyrite-chalcopyrite through pyrite-galena-sphalerite to the heavy galena mineralization of the veins in the Paleozoic sedimentaries on Wet Georgia and Goodrich Gulches. Shipments from one of the principal lead veins averaged approximately 1 ounce of gold, 14 ounces of silver, and 30 percent lead per ton of ore. The Strawn mine in Belle Canyon is characterized by free gold, with a nearly complete absence of sulphide mineralization.

Many claims have been worked on a small scale. So far no mines comparable to the most important mines of the Pony, Norris, or Virginia City districts have been developed, nevertheless there are several attractive possibilities.

From Mill Creek north, the mountains rise abruptly from nearly level alluvial plains. Consequently, only mines on the outer edge of the mountains are easily accessible throughout the year. Many of the mountain roads are in poor repair; notable exceptions are the roads up Ramshorn Creek, Mill Creek, and Bear Gulch.

With the exception of veins on the outer edge of the mountains, particularly the Broadgauge-Tamarack, and the mines on Georgia Gulch, most mines of this area are close to timber and water.

When visited (August 1936), the Sheridan district was producing about 1,000 tons a month, chiefly from the Red Pine mine; the Twin Bridges district was producing about 50 tons a month from a number of small leasing operations.

Agitator

The Agitator mine is on Ramshorn Creek, 10.7 miles by good mountain road from Sheridan, at an altitude of 6,000 to 7,000 feet. It was being operated on lease by L. E. Wright and A. L. Moore. Old gobs, dump ore, and a little newly mined ore were being treated in a small mill.

Five adit tunnels have developed the vein for about 400 feet along the strike and dip. The ore was said to occur in quartz lenses up to 3 or 4 feet wide in a strong fissure in limestone. The strike is N.

10° E.; the dip is 50° west.

The present operators and one extra man were milling about 500 tons of oxidized ore a season. This ore was said to average about $5.00 in gold per ton.

The mill comprised a battery of three 600- to 700-pound (estimated) stamps, dropping at 80 to 100 drops per minute. Battery screens were 40-mesh.

The battery was followed by a 26- by 43-inch amalgam plate, which was followed by two blanket tables, each 26 by 52 inches, used alternately.

Following the blanket tables the pulp passed over an 18-inch by 10-foot launder plate to waste.

Mill capacity was 5 tons of oxidized ore in 8 hours. An extraction of 90 percent was claimed. Of this, 20 percent was obtained on the blanket table.

Power was furnished by a home-made, overshot water wheel, 10 feet in diameter and 3 feet wide, turning 22 to 26 r. p. m., according to the water supply. The water was taken from Ramshorn Creek through a ditch, thence into a 3-foot wide flume built on a slope of 5 feet in 30 feet. The flume delivered the water at a tangent to the upper periphery of the water wheel.

When visited there was an estimated flow of 100 miners inches of water. This was turning the wheel at 22 r. p. m.

Goldschmidt or Steiner

The Goldschmidt group comprises four claims, 11.6 miles by good mountain road from Sheridan on Currant Creek, a northerly branch of Ramshorn Creek. The altitude is probably under 7,000 feet. The mine was owned and operated by Jake Steiner and sons, of Sheridan.

The vein appears to be in the same limestone formation as the Agitator, with which it corresponds in dip and strike. The ore consists of oxidized quartz lenses and stringers along a bedding-plane fault in limestone. "Manganese pockets" are frequent near the ore.

Active development consists of an adit crosscut and about 300 feet of drifting on the vein. A small underhand stope was down 20 feet in ore. This work is evidently on the downward continuation of a vein indicated by old workings and dumps several hundred feet up the hillside.

Mining. - High-grade gold ore was being mined by hand methods and shipped from the lower workings. Ore of less than shipping grade, together with dump ore from the old dumps, was being treated in a small mill.

Milling. - Mine or dump ore was dumped on a 2-inch grizzly, the oversize from which went to a 5- by 7-inch jaw crusher, thence to a small ore bin.

From the bin, ore went to a 10-stamp Straub prospectors mill, thence over a 35- by 90-inch amalgam plate (in two sections), followed by two 33- by 54-inch blanket tables used alternately.

Mill extraction was about 83 percent on $10 to $12 heads. Mill capacity was 12 to 15 tons of oxidized ore in 24 hours. Power was furnished by a McCormick Deering tractor belted to the line shaft.

Cousin Jennie and Cousin Jack

The only active production on Mill Creek was at the Cousin Jennie where the owner, D. T Clemo of Sheridan, was mining high-grade gold ore by hand methods. One man was producing about 1 ton of ore per month.

A quartz vein from a few inches to 10 inches wide was developed by 100 feet of drifts. It was stated that 15 tons of ore had yielded net smelter returns of $1,700.

A nearby parallel vein, known as the Cousin Jack, is developed along a strike length of 50 to 75 feet by two adit tunnels and a short crosscut, from which about 70 feet of drifting has been done. From the lowest drift to the surface is about 150 feet on the dip of the vein. The quartz is 2 to 3 feet wide, but only selected ore is of shipping grade.

Broadgauge-Tamarack

The Broadgauge-Tamarack is in the foothills of the Tobacco Root Mountains, 4½ miles northeast of Sheridan, at an elevation of 6,175 feet. It is owned by the Broadgauge-Tamarack Mining Co., Alexander Leggat of Butte, Mont., manager.

It is estimated that in the early days of the district $200,000 in gold was mined from surface workings on this property. Later production has been intermittent, but some has been reported for nearly every year since 1908. The officially reported production from 1908 to 1935, inclusive, has been 5,055 ounces of gold and 380 ounces of silver from 8,976 tons of ore.

The ore bodies are replacements and impregnations along zones of intense fracturing in limestone near intrusive igneous sheets and masses. There are two intersecting fracture systems, the Broadgauge, striking N. 30° E. and dipping 45° northwest, and the Tamarack, striking east and dipping 35° north.

Recent production has come chiefly from several oreshoots along the Tamarack veins. Most of the early production was, however, from the Broadgauge. This vein appears to contain the stronger oreshoots. Old surface workings extend continuously about 400 feet along its strike, and the lowest adit level cuts it at a depth of 450 feet on the dip, exposing a crushed zone over two sets wide.

The ore is completely oxidized; values are almost entirely in free gold.

On the vein the ground requires close timbering and would require constant maintenance to keep it in good condition. In the crosscuts the ground stands without timbering.

The mine is equipped with a compressor, drilling and blacksmith equipment, and a fair-size mill building which contains a small ball mill followed by a number of plates and traps. It is said that a fair recovery is made by straight amalgamation. A Wilfley table was installed but was not used because of the very small amount of sulphides in the ore.

Power is purchased from the Montana Power Co.

Red Pine

The Red Pine mine had been taken over recently by the White Pine Mining Co., Robert H. Larson, president and manager. The mine is on Indian Creek 8.5 miles by road from Sheridan, at an elevation of 7,800 feet.

The vein fracture crosses a limestone-gneiss contact; the strike is about N. 20° E. and the dip 50° west. The productive oreshoots have all been in the limestone. These oreshoots were strong, lenticular bodies of quartz. In the gneiss the vein fracture is well-defined and in places contains narrow but well-mineralized quartz veins. Ore bodies in the limestone had averaged 4 to 5 feet in thickness and had in places been 10 feet in thickness.

Development. - The upper workings, from which all production had come, were developed by a short crosscut adit and about 500 feet of drifting. A winze was being sunk on the vein. This showed a strong face of ore in the bottom, 135 feet below the adit level. Stopes had been worked at intervals along the entire length of the drift; the main stope was about 150 feet long and extended to the surface, a distance of 100 to 200 feet.

A 1,700-foot adit crosscut in gneiss intersected the vein 640 feet on the dip below the upper workings. A drift was being driven northeast along the fracture to explore the vein in the limestone.

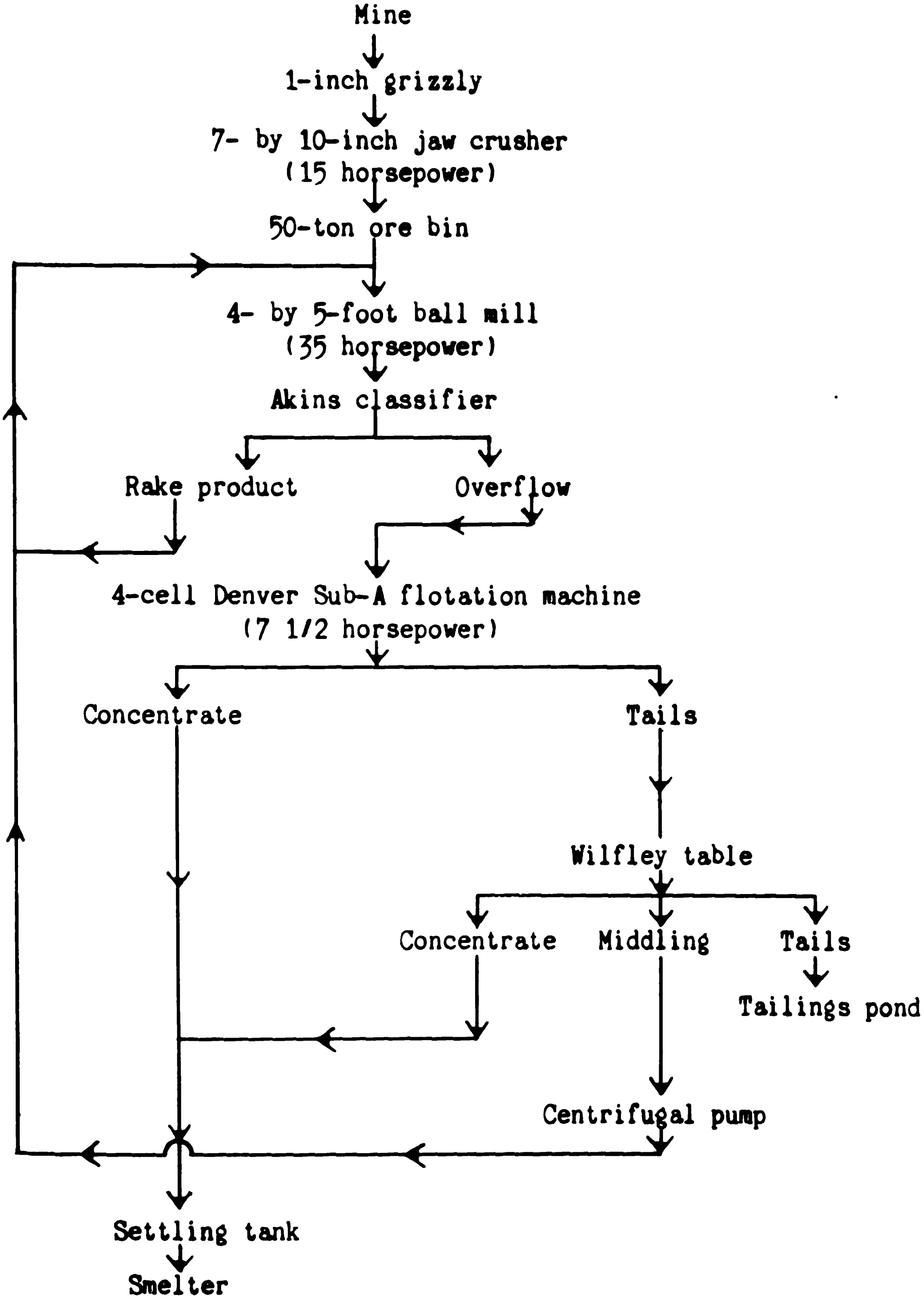

Figure 13.- Flow sheet, Red Pine mill.

About 1 cubic foot of water per second (estimated) was flowing from the crosscut.

Equipment. - An Ingersoll Rand 10- by 12-inch compressor, driven by a 50-hp. motor, supplied air for mining.

A 900-foot "jig-back" tram, with buckets of 400-pound capacity, carried 40 tons of ore in two shifts from the upper workings to the mill.

A 50-ton flotation mill had recently been completed. This was situated just below the lower crosscut adit.

Mining. - An open-stope, overhand mining method was used. The back was supported by stull and headboard only. The stope outlines were irregular; areas unsupported by pillars or tongues of waste were not large.

Milling. - The mill flow sheet is shown in figure 13.

Ore from the tram was dumped on a 1-inch grizzly; the oversize went to a 7- by 10-inch jaw crusher thence to a 50-ton ore bin.

A 4- by 5-foot Denver, Marcey-type ball mill, operating in closed circuit with an Akins classifier (11-foot by 26-inch spiral), ground the ore to about 100-mesh.

Classifier overflow went to the first cell of a 4-cell Denver Sub-A, No. 18 flotation machine. Reagents used were:

	Pound per ton
Sodium ethyl xanthate............................	0.3
Pine oil...	.09

A finished concentrate, assaying 7 to 9 ounces in gold and about the same in silver, was taken from the first cell.

Flotation tails went to a Wilfley table which produced a final tail, a 1-ounce middling which was returned to the ball mill, and a concentrate assaying about 2 ounces in gold. The table concentrates were chiefly hematite carrying gold.

Concentrates were dewatered in a settling tank.

Recovery was 85 to 90 percent on $10 heads. The ore contained a high percentage of oxides.

Connected power for milling was as follows:

	Hp.
Crusher	15
Ball mill	35
Flotation	7½

Power was purchased from the Montana Power Co.

Labor. - Nineteen men were employed at the mine and mill; these were distributed as follows:

Miners and muckers	11
Mine foreman	1
Crusher men (1 each shift)	2
Mill operators (including foreman)	3
Tailings dam attendant	1
Manager	1

Lucky Strike

On Indian Creek, 11½ miles from Sheridan, the Lucky Strike mine was being operated by Ole Moe and Sam Hagenberger. The elevation is about 9,500 feet. There is a road to the mine, but the last 1½ miles cannot be traversed by automobile.

A quartz vein up to 3 feet in width strikes east and dips 45° to 60° north. It was developed by a 90-foot shaft at the 30-foot level where there was about 50 feet of drifting. About 100 feet below the shaft was a 245-foot crosscut adit from which there was 30 feet of drifting on the vein.

Two shipments, one of 7 and one of 12 tons, were said to have assayed $41 and $27 a ton, respectively, in gold and silver.

A recently installed Gibson prospector mill, driven by an old automobile engine, was grinding 1,400 pounds of oxidized ore in 7 hours. Fuel consumption was 5 gallons of gasoline per shift.

Fairview

The Fairview mine was being operated by the Fairview Gold Mines, Inc., Byron Felton, manager. The mine is on Wisconsin Creek 6½ miles from Sheridan at an elevation of about 6,000 feet.

Active development comprised an adit crosscut and several hundred feet of drifting. One oreshoot had been actively mined during the year. This oreshoot was a "chimney" or "pipe" along a bedding plane in limestone. It was 10 to 20 feet long and 2 to 4 feet thick and had been mined about 100 feet above and 200 feet below the drift. It was apparently localized along a channel formed by the slipping of one limestone bed over the other. The ore consisted of highly oxidized quartz stringers and replacements along the bedding-plane fault. The degree of oxidation indicated a heavy original sulphide mineralization. It was stated that 740 tons shipped in the last year had averaged $43 a ton in gold.

Ore remained in the bottom of the stope, but hoisting along the irregular stope had become so difficult that it had been decided to discontinue stoping and resume drifting on the main level to a point under a strong surface showing, some distance ahead. There were about 500 feet of "backs" over the drift.

The mine was equipped with a 220-cubic foot Gardner Denver portable compressor, blacksmith shop, change room, and ore bins.

Lakeshore or Gladstone

The Lakeshore or Gladstone mine is at the head of Wisconsin Creek at an altitude of 8,600 feet. It is reached from Sheridan over 12 miles of mountain road, the last 3 or 4 miles of which was steep and rough.

The mine had been extensively developed and completely equipped in comparatively recent years but had been idle since about 1929. When it was visited five men, under the direction of Wm. H. Mader, were reopening the old workings for examination. This work was being done for the owners, the Piedmont Co. of Reno, Nev.

The old stopes were not yet accessible. It was said that the ore bodies were quartz fissure-veins in gneiss. Reported production from 1910 to 1929 was 2,436 ounces of gold, 7,288 ounces of silver, and 7,154 pounds of copper from 4,317 tons of ore. A concentration ratio of about 8 to 1 is indicated by the production records.

The mine was equipped with a 100-ton cyanide plant and complete mine equipment in various stages of repair.

Power had been obtained from the Montana Power Co., whose lines crossed the property.

Highridge and Highridge Fraction

The Highridge claims are on the ridge above Georgia Gulch 6 miles by road from Twin Bridges at an elevation of about 7,000 feet. The original locations appear to have been made on a flat-lying, bedding-plane vein between gneiss and shale. This vein, or related veins, is continuous through the Highridge, Sunflower, and other claims, being traceable by surface workings for several thousand feet along the contour of the hill. Oreshoots comprised a few inches to several feet of massive sulphides, chiefly galena said to assay about 1 ounce of gold and 15 ounces of silver per ton. When the mine was visited no work was being done on the galena vein.

Otis Shaw and Alfred Ellis were working separate claims on a gold-bearing vein in gneiss. This was a small fissure vein striking N. 30° E. and dipping 70° to 80° southeast. The vein was in gneiss, terminated upward against the shale, and was slightly displaced by the galena vein where the two intersected. Narrow stringers and bunches of high-grade, oxidized gold ore were being mined by hand methods. These small shoots had been worked at various points along a strike distance of 600 or 700 feet.

Corncracker

The Corncracker adit strikes S. 30° W. about 2,000 feet from the Highridge. The elevation is about 6,000 feet.

According to Hart[17] the ore comprises bands of heavy sulphide ore in a strongly fissured or sheared zone in gneiss. The strike is N. 30° E. and the dip 70° southeast.

Although the mine was inactive when visited it has been one of the more consistent producers in the Tidal Wave district since 1920; considerable high-grade ore had been shipped in recent years. Officially reported production from 1921 to 1935 has been 2,419 ounces gold and 1,899 ounces of silver from 1,133 tons of ore. The ore also contained a little copper.

Mountain View

The Mountain View mine is on Georgia Gulch 7.3 miles by road from Twin Bridges, at an altitude of about 7,000 feet. It was being operated on lease by Ray Mackinson of Butte, Mont.

The ore comprised quartz and silicified limestone along a bedding-plane fault in limestone. The oreshoots were 4 to 5 feet thick and irregular in outline. Stoping had begun at the surface and continued about 100 feet along the strike and dip of the vein. The ore was almost completely oxidized; it was said to assay from $\frac{1}{4}$ to $1\frac{1}{2}$ ounces in gold per ton.

Equipment consisted of a one-drill compressor, driven by an old automobile engine, and an inclined surface tramway, several hundred feet long, used to lower the ore to ore bunkers on the truck road.

In 7 weeks two men had built the tramway and shipped 2 cars of ore.

Hawkeye

Several hundred feet west of the Mountain View a pipe of oxidized gold ore 80 feet long on the dip by 30 feet long on the strike by 4 to 8 feet thick had been mined and shipped. The ore had occurred as replacements along bedding-plane fractures in limestone. The walls were heavily stained with manganese oxides. The strike of the bedding was roughly east and west; the dip was 20° to 25° north.

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[17] Hart, Lyman H., A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Mont.: Montana Bureau of Mines and Geology, Mem. 9, pt. 2, 1933, pp. 34-37.

About 600 feet almost vertically below the stope a crosscut had been driven due north. It was said to have encountered sulphide ore at 1,250 feet but was inactive when visited.

Bielenberg and Higgins and Pete and Joe

The Bielenberg and Higgins mine, of which the Pete and Joe is a part, is at the head of Bear Gulch at an elevation of 8,400 feet. A comparatively new sidehill road on a 6-percent grade connects the mill camp with Twin Bridges 13.6 miles distant. It was stated that a small amount of snow plowing had kept this road open for winter use.

The mine had been completely equipped by the Inspiration Gold Mining Co. A new 250-ton mill, mining equipment, and camp buildings, all in good condition, were on the ground. A mill-level crosscut had been driven 1,300 feet, approximately halfway to the expected downward extension of the main vein.

At an elevation 500 feet higher than the mill level was the old "B and H" tunnel, through which most of the past production had been mined. This tunnel cuts several fissure veins and a shear zone containing quartz stringers; about 800 feet from the portal it intersects the Pete and Joe vein, which has been the chief producer.

On an adit level several hundred feet above the B and H, Sylvan Dunegan and two partners were mining and shipping high-grade ore from the Pete and Joe vein. The shipping ore consisted of a band of heavy sulphides, 1 to 6 inches wide, along one wall of a small quartz vein. The sulphides were said to assay about $200 a ton, chiefly in gold. Three tons a month were being shipped under lease from the Inspiration Gold Mining Co. Drilling machines and power were furnished by the company.

In the hanging wall, 8 feet from the high-grade vein, a short crosscut had recently exposed a well-mineralized sheeted zone, or lode, 15 feet wide. No lateral development work had been done on this showing.

All veins on the B and H property are in a monzonite-stock intrusive into gneiss and schist. The Pete and Joe is a tabular quartz fissure vein; it strikes N. 35° E. and dips 40° to 50° northwest. Other veins differ somewhat in character, strike, and dip.

Schmidt Claims

On the south slope of Goodrich Gulch, 9 miles from Twin Bridges, A. B. and W. H. Schmidt and partners were mining and shipping gold-silver-lead ore from two adjoining claims. The same vein, slightly faulted, is continuous throughout both claims. The ore is found in narrow stringers along a bedding-plane slip between shale and quartzite. The same vein or related veins have been productive at intervals for several claim lengths. The largest ore bodies were said to have been on the property of the Crystal Lake Gold Mining Co. where, on the Sunbeam vein, the ore was supposedly 6 to 18 inches wide.

Sulphide mineralization consisted chiefly of coarse galena.

Strawn

The Strawn mine camp is in Belle Canyon 5 miles by road from Waterloo Station at an altitude of 5,250 feet. The mine is on the mountain south of the canyon at an altitude of 7,100 feet. There is 2 miles of good pack trail from the lower camp to the mine. J. E. Strawn, of Silver Star, Mont., is owner and operator.

High-grade gold ore has been found in silicified limestone beneath conformably overlying shale. Small basic dikes or sills are associated with the ore and in places divide it into an upper and a lower vein. The dip conforms to the bedding; it ranges from nearly flat to about 35°. The ore is 2 to 5 feet thick, and oreshoots are irregular, which is characteristic of limestone replacements. There is virtually no sulphide mineralization; all values are in free gold.

Production is estimated at more than $50,000 chiefly from shipping ore.

Development is by two adit drifts. On the upper, or no. 2, tunnel level, a stope about 100 feet long has yielded most of the past production. Practically no timber was required in stoping. At an elevation 133 feet lower, no. 3 tunnel follows for several hundred feet a brecciated and silicified limestone bed carrying low gold values. Except for one small faulted segment, no. 3 tunnel does not pick up the banded limestone or shale contact found in the oreshoot on the upper drift. A strong postmineral fault cuts the formation between the upper and lower drifts.

The mine is equipped with a compressor of 265-cubic feet (sea-level) rating, driven by a 50-hp. Novo gas engine. There are good log cabins at both the upper and lower camps.

Near the lower camp is an old 5-stamp battery. There is also a comparatively new prospectors' mill consisting of a 3- by 5-inch Ellis jaw crusher, a 22-inch-diameter Ellis mill, and an Ellis amalgamator. This mill was said to have a capacity of 120 pounds of hard quartz per hour.

Shipping ore is hauled from the mine to the lower camp by rawhide in winter or sled in summer. One horse hauls 1,200 pounds per

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trip. From the lower camp the ore is hauled by wagon about 1 mile to the mouth of Belle Canyon and by truck the remaining distance to Waterloo Station. Transportation from the mine to the canyon mouth was said to cost $4 per ton; trucking cost $1 per ton.

An aerial tramway from the mine to the lower camp would be 3,600 to 3,900 feet long.

Water power and timber are available in Belle Canyon.

Renova District

Except for the recent development of the Mayflower mine and a small amount of leasing on Gold Hill this district was inactive in 1936; it had been inactive for many years.

The Gold Hill, Surprise, Mary Ingabar, Colorado, Blue Bird, Mayflower, and other mines had produced ore in the early days. Of these the Mayflower is the most noteworthy. Under the ownership of the Clark interests, the Mayflower is said to have produced considerably over a million dollars of high-grade gold ore between 1896 and 1901; some estimates place the production nearer 3 million dollars.

The mines of the district are in barren foothills on the northern end of the Tobacco Root Range; they are chiefly in rocks of the Belt series. According to Hart[18] these are the only mines of the Tobacco Root region that occur in Beltian rocks.

None of the mines were accessible except the Mayflower. The Mayflower had recently been reopened and was producing direct-shipping ore encountered during exploratory work.

Mayflower

The Mayflower mine is about 9 miles by road southeast of the town of Whitehall. Under the direction of the Anaconda Mining Co., the West Mayflower Mining Co. was exploring for new ore bodies under, or adjacent to, the old Mayflower workings. Some ore had already been discovered.

The Mayflower ore bodies are believed to be "chimneys" or pipelike replacements and impregnations in brecciated limestone adjacent to a major fault. The ore so far mined has been highly oxidized; tellurides are said to have constituted part of the primary mineralization. The ore is of direct-shipping grade.

Recent developments comprised an adit drift and a 160-foot vertical shaft. An exploratory drift was being driven from the bottom of the shaft. One square-set stope was being worked.

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[18] Hart, Lyman H., work cited in footnote 17, pp. 31-32.

The mine was equipped with a 450-cubic foot compressor, driven by a 75-hp. motor, shops, cookhouse, and bunkhouse. A single-drum hoist was driven by a 50-hp. induction motor.

SUMMARY

Mining

Most properties in the region are already partly developed; many mines contain oreshoots that have been partly or wholly worked out above the water level but have not been explored below the water level. Therefore, although sinking will usually be necessary in the future it will frequently be possible to sink on known ore showings.

Large shafts are not necessary or desirable for ore bodies of the size found in this region. Deep shafts will not be required for some time. As sinking costs are roughly in direct proportion to the size and depth of the shaft initial sinking costs will be comparatively low. At the Rosebud mine (p. 42), 125 feet of 3- by 7-foot inclined winze was sunk in dry ground at an over-all cost of $13.80 a foot. Experience elsewhere under similar conditions indicates that small shafts suitable to this region can be sunk for a direct cost of $20 to $40 a foot, depending on the size and depth of the shaft.

Drifts or crosscuts larger than 5 by 7 feet in cross section will seldom be required. An examination of drifting and crosscutting costs at a number of mines in North America[19] indicates that the total direct cost of drifting and crosscutting in ground of this kind is usually between $8 and $10 or $11 a foot.

Development work in ore is usually in quartz with more or less gouge and crushed wall rock. The country rock is usually a blocky gneiss or a quartz monzonite. Timbering is seldom necessary in crosscuts. In drifts the amount of timbering required depends upon the width and intensity of the shearing; close timbering is rarely necessary.

Nearly all stopes are mined by open, overhand methods. Usually the ground stands well and may be adequately supported by irregularly spaced stulls with headboard or by widely spaced half sets. In a few mines the dip is steep enough to permit shrinkage stoping. In most veins, however, the dip is too low to permit gravity flow of ore to the chutes; broken ore is scraped to the chutes by hand, often on plank slides. The writer believes that small mechanical scrapers could be used frequently to great advantage; they are being used successfully, under similar stoping conditions, at the Golden Messenger mine, York, Mont.[20]

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[19] Jackson, Chas. F., Summary of Drifting and Crosscutting Cost Data: Inf. Circ. 6825, Bureau of Mines, 1935, 14 pp.

[20] Lorain, S. H., Mining and Milling Methods and Costs at the Golden Messenger Mine of the United Gold Mines Corporation, York, Mont.: Inf. Circ. 6947, 1937, 14 pp.
For summarized data on stoping methods and costs see Jackson, Chas. F., and Gardner, E. D., Stoping Methods and Costs: Bull. 390, Bureau of Mines, 1936, 296 pp.

Detailed analyses of stoping costs in this region were not available. Suggestive figures, however, are given under the description of stoping methods at the Prospect mine (p. 50).

Milling

Milling practice is simple and generally uniform. All plants operating in 1936 were using bulk flotation, supplemented in some instances by plates, blankets, traps, or unit flotation cells for the recovery of coarse free gold or partly oxidized sulphides. The only cyanide plant in the region was idle.

Mill recoveries of 90 to 93 percent by straight flotation are easily obtainable on the sulphide ores of the region. Flotation recoveries, however, fall off as the proportion of oxidized ore in the feed increases. As most mines are producing some oxidized ore it is usually advisable to make provision for recovering coarse free gold and partly oxidized sulphides.

One mine in the Virginia City district is making a high recovery on partly oxidized ore by interposing a hydraulic trap in the ball mill-classifier circuit. In other gold-mining regions an excellent recovery has been obtained on partly oxidized ore by the use of plates or corduroy blankets in the ball mill-classifier circuit and additional plates or blankets to treat the classifier overflow; the sulphides are then recovered by flotation.

One mine in the Tobacco Root region and numerous mines elsewhere have found the use of a unit flotation cell in the ball mill-classifier circuit to be a decided advantage in the treatment of sulphide ores containing coarse free gold. It is doubtful whether or not this cell is of much advantage in the treatment of oxidized ore.

The ratio of concentration in the region ranges from 10 : 1 to 40 : 1. The lower ratios were usually found in the Pony district where less oxidized ore was being treated. Probably the ores of the Pony district are actually more highly mineralized than the average ores of most other districts.

Costs

The costs of two established operations in the region are given under the description of the Marietta mine (p. 58) and the Mammoth mine (p. 30). These mines are operating on ore bodies typical of the quartz veins of the region. If allowance is made for unusually heavy exploration costs at one mine the costs of mining and milling at the two properties are very similar. A comparison with data obtainable at other operations indicates that these figures are fairly representative of direct operating costs throughout the region.

Summarized in round numbers these costs per ton are about as follows:

Mining:	
Labor	$2.00
Supplies and power	1.00
	3.00
Milling	1.65
General expense	1.00
Total	5.65

The ore at these two properties was being obtained from above the adit level or a short distance below it. Power costs may be expected to increase with depth. On the other hand, a large part of the ore was being obtained from development work, and ore from developed stopes will be cheaper.

It is to be expected that development costs will always be high in these small veins and that at times exploration costs will be exceptionally high; these costs will considerably increase the costs given here. Interest, amortization, taxes, and royalties must, of course, be added to the direct operating cost.

General

Mining operations in the Tobacco Root Mountains are favored by the availability of many partly developed ore bodies possessing possibilities of profitable operation at present metal prices. Underground conditions are generally favorable, metallurgical problems are simple, electric power is available, most mines are easily accessible, and two large custom smelters are within 50 to 85 miles of the northern end of the region.

On the other hand the ore bodies so far developed are small, and the average value of the ore is such that the margin of profit is often low.

Skilled management and conservative financing are essential to success. It is doubtful if a plant of much more than 100 tons daily capacity would be justified at present at any mine in the region; at nearly all mines a 50-ton, or smaller, plant would be more suitable. The necessity of maintaining low costs, even though small tonnages are handled, requires careful plant design, compact lay-out, elimination of unnecessary labor, and minimum overhead.